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AN EXPERIMENTAL STUDY ON LEARNING BY PROVIDING
INDIVIDUAL LABORATORY EXPERIMENTS IN THE
JUNIOR HIGH SCHOOL

by

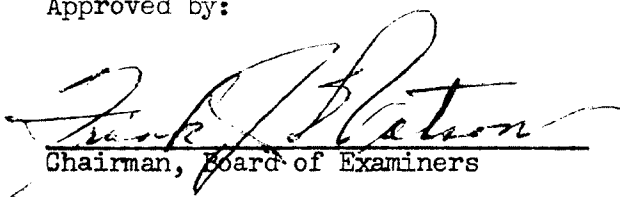
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B.S. Jamestown College, 1958

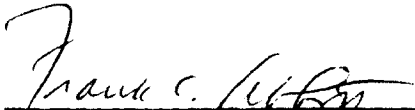
Presented in partial fulfillment of the requirements for the degree of
Master of Education

MONTANA STATE UNIVERSITY

1962

Approved by:


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CHAPTER I

THE PROBLEM AND DEFINITIONS OF TERMS USED

The world we live in has changed immensely in the last two decades. With each new Soviet success in politics and space technology, our past policies in many fields of endeavor are being questioned. Subject matter and teaching methods are being more carefully examined. This questioning gives rise to studies which compare the results obtained from teaching methods employing different laboratory procedures in science. This will be that kind of study.

I. THE PROBLEM

Significance of the problem. Educators, particularly those in the field of science, agree that the need for recruitment of scientists is ever increasing. This need has been brought to our attention as a result of World War II, and more recently, the "Cold War." Dr. Hurd, an associate professor in the School of Education, Stanford University, and a specialist in the teaching of science, has said, "We are undergoing a revolution in science, creating a new partnership with the economic, social, educational, and political issues of our times."¹ It has also been pointed out that, "Applications of science to technology open the way for new industrial enterprise, and successful exploitation of this

¹Paul DeHart Hurd, "Teaching Science in a Changing Society," California Teachers Association Journal, 57:14, May, 1961.

frontier will require increased attention to the training of scientists."²

In respect to this training, Dr. Hurd goes on to say, "The demands of present day knowledge demands that significant knowledge be taught as early in school as it is comprehensible."³ He extends the view that in the next few years we can expect a migration downward of course content from college to high school, to junior high school, to elementary school.

To meet this migration and encourage the training of scientists, teachers and administrators in junior high schools are wondering if their science rooms should be equipped to carry on individual laboratory work. Dr. Hurd has said.

A distinguishing and presumed essential feature of any science teaching is the laboratory work. For at least the past thirty years, those in science teaching have had a hard time convincing either school administrators or scientists that the time spent in the usual activities of the typical laboratory produced anything that was valuable to either one's education or an understanding of science. Every committee that has considered the science curriculum has recognized the need to improve laboratory work.⁴

To encourage students to find a career in science, teach the processes of inquiry rather than outmoded facts, and provide students with an entrance into this knowledge, an attempt has been made to develop an interest in the processes of inquiry and measure any outcomes that might appear. At West Junior High School the science faculty considered the following questions: Should the science rooms be equipped to carry

²Vannevar Bush, Modern Arms and Free Men (New York: Simon and Schuster, 1949), p. 78.

³Hurd, op. cit., p. 15.

⁴Ibid., p. 15.

on individual laboratory experiences? Are there any measurable outcomes of individual laboratory work in a seventh grade course of general science? What effect does laboratory work have on the students' ability to succeed in an examination based on the subject matter of the course, or the ability to solve laboratory problems? What method of teaching is preferred by the students at this grade level?

Purpose of the study. The purpose of this study was to compare the individual work method and the lecture-demonstration method of laboratory instruction in seventh grade general science, West Junior High School, Great Falls, Montana. Subproblems included in this study were: What were the pupils' preferences as to the two teaching methods employed? Did individual laboratory work encourage pupils to work harder? Did it help pupils retain facts longer? Which method was better in teaching the processes of inquiry, and the ability to solve problems? How might the present laboratory space, funds, and equipment be used most effectively? What was the relation between learning and the use of laboratory exercises in seventh grade general science? And finally, what method of conducting laboratory work seemed to be the most effective for the writer?

II. ASSUMPTIONS, DELIMITATIONS, AND LIMITATIONS

Assumptions. It will be assumed that (1) the results of past achievement tests, intelligence tests and other information on the cumulative records of the school are sufficiently accurate and show what they were intended to show; (2) the individual laboratory method does present a change in the conditions for learning, and therefore has some effect,

good or bad, upon the child's learning in science; and (3) the groups compared represent typical classes and students in the general science program of the school.

Delimitations. (1) The students in the experimental group may have become aware of the testing and unconsciously reacted to it. (2) No pretest was given to measure the elementary science background of the seventh grade students. (3) No facilities and little laboratory equipment was available for carrying on individual laboratory work.

Limitations. (1) Only seventh graders in one junior high school under one teacher were considered. (2) The data analyzed were the results from one year and six specific units of study.

III. DEFINITION OF TERMS USED

The junior high school. This term will refer to West Junior High School, Great Falls, Montana, and more specifically to students in the school.

The individual laboratory work method. This method is the method wherein the pupils work singly or in small groups in the laboratory and actually do the experiments themselves. The pupils may be given specially prepared mimeographed directions and apparatus for the experiment, but no further help is given.

The demonstration method or the lecture-demonstration method.

This method is the method wherein the teacher performs the experiment in front of the class without student participation. Explanations are given to the class orally by following the mimeographed directions verbatim. The same apparatus is used in both methods.

The individual laboratory work group. This group consists of those classes actively participating in laboratory activities and exercises.

The lecture-demonstration group. This group consists of those classes not participating in laboratory activities.

CHAPTER II

REVIEW OF THE LITERATURE

The question of the use of the individual laboratory method or the lecture-demonstration method for teaching science has long been debated. Most of the research on this subject took place near the beginning of the twentieth century when the schools were faced with the necessity of teaching large numbers of students, often in large classes. As schools grow in size, and their financial burdens increase, the cost of equipment, supplies, service facilities, furniture, and specialized rooms becomes very important indeed. As Dr. Hurd has pointed out, many school administrators and scientists alike have seriously doubted the value of laboratory work.¹

I. LITERATURE ON EXPERIMENTAL STUDIES IN THE HIGH SCHOOL

Most of the research that has been carried on has been conducted in the higher grades of the secondary schools in the subjects of chemistry, biology, and physics. There was little specific information on any studies that have been conducted in the elementary grades and particularly in grades seven and eight.

¹Hurd, op. cit., p. 15.

In one comparison of the lecture-demonstration and individual laboratory work method of instruction, Anibal² attempted to determine in an experimental study, using merely objective methods, if adequate instruction could be given by the lecture-demonstration method as efficiently, if not better than by the individual laboratory method in a high school chemistry class. He took two classes that were equal in mental ability and balanced them by shifting students from one class to another. One class was taught by the regular procedures of individual laboratory work and the other by the lecture-demonstration method in which students had no contact with apparatus or chemical materials. Both of the groups were tested by using the same objective test. When the results were compared, the inference was that the lecture-demonstration method consistently gave better results all the way through the study. This he believed was due to the fact that there was less distraction, no novelty of apparatus and no setting up of the equipment to perform the experiment. Among other experimental studies with similar findings may be mentioned a study by Coopriders,³ and one by Cunningham.⁴

R. E. Horton⁵ reports opposing findings in an experimental study

²Fred G. Anibal, "Investigations of Demonstration Versus Laboratory as a Method of Teaching Natural Science," National Education Association, Addresses and Proceedings, 26:761-2, 1924.

³J. L. Coopriders, "Oral Versus Written Instruction and Demonstration Versus Individual Work in High School Science," School Science and Mathematics, 22:838-844, 1922.

⁴Harry A. Cunningham, "Laboratory Methods in Natural Science Teaching." School Science and Mathematics, 24:709-715, 1924.

⁵Ralph E. Horton, Measurable Outcomes of Individual Laboratory Work in High School Chemistry, (New York: Teachers College, Columbia University, 1928), p. 97.

which may be used to determine a technique for testing and measurement in this study as well as to provide a background of past work in this area. In order to decide for one school how to utilize the laboratory to its best advantage, he found that in the written and non-written mid-term tests, the scores of the individual laboratory trained group were higher than those trained by the demonstration method and that the pupils expressed a preference for the individual laboratory method by a vote of eighty-seven per cent. In support of the importance of laboratory work, Noll⁶ found that when two groups with similar instruction were compared, the section having the greater amount of laboratory work showed consistent superiority in general achievement. Moreover, when laboratory work was reduced from five to three hours each week, and two hours of library study was substituted, there was a loss in general achievement.

In contrast to the studies already mentioned, William H. Wiley⁷ compared the textbook, demonstration, and the individual laboratory methods used in teaching high school chemistry. He found that there was not as great a difference as was ordinarily supposed in the values of the three methods. He concludes that a combination of the three methods will probably give the best results in the teaching of high school chemistry.

⁶Victor Herbert Noll, Laboratory Instruction in the Field of Inorganic Chemistry. (Minneapolis: The University of Minnesota Press, 1930), pp. 109-110.

⁷William H. Wiley, "An Experimental Study of Methods of Teaching High School Chemistry." The Journal of Educational Psychology, 9:181-198, April, 1918.

II. LITERATURE ON HISTORICAL SUMMARIES OF STUDIES IN THE HIGH SCHOOL

A historical study of what had happened in this field of research was prepared by Harry A. Cunningham.⁸ This summary reviewed the research done by fifty-two experimenters over a period of about twenty-five years. Most of the research took place near the end of the nineteenth century and the beginning of the twentieth century. The sources were scattered widely over the United States. One researcher⁹ secured data from fourteen states. Out of these studies, the variable that seemed to have been common to thirty-seven of the studies was in the field of method and pertained to the manner of giving the laboratory experiences in science. Under one method, the pupils gained their experiences by observing experiments or laboratory exercises that were set up and manipulated by someone, generally the science instructor. Under the other method the pupils themselves performed experiments and laboratory exercises, made observations, and manipulated materials. One study covered a period of two years, seven covered a period of one year, fourteen covered one semester, and the others covered less than one semester. Out of all the studies reviewed, only one was done in the elementary grades.

In the results that were reported by these experimenters, twenty

⁸ Harry A. Cunningham, "Lecture Demonstration Versus Individual Laboratory Method in Science Teaching." Science Education, 30:70-82, March, 1946.

⁹ W. W. Carpenter, "Certain Phases of Administration of High School Chemistry," Doctor's thesis, Teachers' College, Columbia University, New York, cited by Harry A. Cunningham, Science Education, p. 70.

definitely favored the lecture-demonstration method. Six favored the individual laboratory method, two believed there was no difference, and the others were noncommittal. In twenty-four studies that gave specific attention to delayed results, such as the ability to solve problems independently or develop processes of inquiry, ten studies favored the lecture-demonstration method, eleven favored the other, and three reported no significant differences. In seven studies that gave specific attention to the amount of interest that seemed to be stimulated in the pupils by the two methods, three studies favored the lecture-demonstration method, four favored the other. All fifteen of the studies that gave attention to the time that was required by each of the two methods reported a saving of time under the lecture-demonstration method. These studies also indicated that slight indications were found that the lecture-demonstration method was better for helping pupils understand the reason for following a certain method of procedure, the trait of self-reliance was developed better in students by the individual laboratory method, the trait of attentiveness to the real scientific problem at hand was better developed by the lecture-demonstration method, and under this method the subject was more fully covered. The value of the two methods in providing for individual differences was given attention in four studies. One favored the lecture-demonstration method, three favored the other. Several of these reported that the lecture-demonstration was less expensive. Van Horne¹⁰

¹⁰D. Van Horen, "An Experimental Comparison of Demonstration and Individual Laboratory Methods in High School Chemistry," Masters' thesis, University of Southern California, Los Angeles, 1929, cited by Harry A. Cunningham, Science Education, p. 77.

points out that the cost for demonstration was about 4.4 per cent of the cost of individual laboratory work. Therefore, he believed that if all the work in his study had been done by the lecture-demonstration method a savings would have been made of approximately 95.6 per cent on apparatus, materials, and the gas and water used.

In the light of the results made available by these studies, Cunningham¹¹ suggested that the lecture-demonstration method should be used if (1) ordinary written tests are to be used; (2) the learning involved in connection with the exercise is complicated and difficult; (3) the apparatus used is complicated, difficult to manipulate, or expensive; (4) the apparatus used is sufficiently large to be seen at a distance; (5) the students are likely to make mistakes when working alone; (6) a large amount of subject matter must be covered in a limited time; and (7) supplies are limited.

Cunningham's survey also suggests that the individual laboratory method might be used if (1) the laboratory exercises are short and easy; (2) the apparatus is not too complicated; (3) caring for individual differences seems especially desirable; (4) the results can be easily seen and understood by the pupils working alone; (5) several observations are to be made over a period of many days or weeks; and (6) one desired outcome of the program is the development of laboratory skills, or the ability to solve laboratory problems.

¹¹Cunningham, op. cit., p. 80-82.

Stuit and Englehart,¹² in their summary of methods in teaching high school chemistry, favored neither method but insisted that it would have been better to have had the demonstration group taught by a teacher especially good in demonstration and the laboratory group taught by another teacher who was equally good in conducting individual laboratory work.

III. LITERATURE ON STUDIES IN THE ELEMENTARY SCHOOL

Very little specific information concerning the comparison of the lecture-demonstration and the individual laboratory work method in the elementary school is available. Jacqueline Buck,¹³ in a historical study, attempted to summarize the findings of all recent research in the teaching of elementary science published from 1929 to 1952. The question of method of laboratory work was omitted and she concluded that one area in particular that needed to be investigated was, "the use of laboratory exercises on the elementary level."¹⁴

¹²Dewey B. Stuit and Max D. Englehart, "A Critical Summary of the Research on the Lecture-Demonstration Versus Individual Methods in Teaching High School Chemistry," Science Education, 16:380-391, October, 1932.

¹³Jacqueline V. Buck, "Implications of Recent Research in the Teaching of Science at the Elementary School Level," Science Education, 38:81-101, February, 1954.

¹⁴Ibid., p. 100.

CHAPTER III

METHOD OF PROCEDURE

COLLECTION OF DATA:

Determination of intelligence quotient. All seventh graders entering West Junior High School were given a battery of tests to help the school staff meet their needs more exactly. The Otis Beta Quick Scoring Mental Ability Test was used as a measure for determining their intelligence quotients.

Selection of the control and experimental groups. When the test scores had been analyzed the teacher decided what classes were to be in the experimental individual laboratory work group and the lecture-demonstration groups by random sampling. Randomness here was provided for by drawing out of a hat similar and well-shaken-up slips of paper containing the number of the class section. The first three slips drawn out of the hat made up the controlled or lecture-demonstration group. The remaining slips made up the experimental or individual laboratory work group. Each group was made up of three classes of seventh grade science students. Both groups received the same classroom instruction from the same teacher. The only difference was the method in which the laboratory exercises were performed. In the lecture-demonstration group the laboratory work was performed by the teacher; the students listened and watched either from their seats or from the periphery of the demonstration table. In the individual laboratory work group, the work was

presented by the individual laboratory work method in which the students perform as many of the activities as possible by following either written or oral instructions from the teacher.

The pretests and final tests. Before a unit was studied, a pre-test made up of review questions suggested by the author of the textbook was administered to each group.¹ The unit was then studied and at the conclusion of the unit, a teacher-made objective test was given. The results of the final unit tests were used as the basis of comparison of these groups. Both groups were given daily reading assignments and asked to write out the answers to the questions at the end of each section in their texts.

The use of experiments. There were forty-four experiments used in this study. Thirty-four of these were completed by the individual laboratory work group; ten were demonstrated to both groups by the teacher because of their dangerous or complex nature. One experiment not included in the forty-four mentioned above was performed by everyone in an effort to detect differences such as preferences of method and problem solving ability.

Unit activities. One experiment used in the first unit on fire was demonstrated to both groups because it was believed to be too dangerous to be performed by unskilled students. (Hydrogen was generated by using zinc and acid.) Eight experiments were used in the study of this unit. Seven experiments were completed by the individual laboratory work group.

¹Ira Davis, John Burnett, and E. Wayne Gross, Science Observation and Experiments (New York: Henry Holt and Company, Inc., 1958).

In the next unit on water, five experiments were done independently by the individual laboratory work group. Three were demonstrated by the teacher to both groups. These were (1) a demonstration of the water cycle using a terrarium, (2) the distillation of fresh water from salt water, and (3) how water vapor forms clouds, or the making of a cloud in a bottle.

The next unit on weather did not have as many activities that could be completed individually by the laboratory group. However, after the pretest, the laboratory group did complete activities demonstrating convection currents, differences in heating due to the angle of the sun's rays, how a hygrometer works, and in small groups of three to five, the students were responsible for building and explaining the operation of the various weather-measuring instruments. Six experiments were completed; three were demonstrated to both groups by the teacher.

The unit on sound lent itself to a few more demonstrations. These could be performed in class and individually by the laboratory group. In an activity designed to prove the necessity of air for sound, the laboratory group worked in groups of five with the bell jar. The same groups were used to determine (1) how sound waves could be controlled, (2) why some sounds are pleasing and others are not, and (3) how some musical instruments make sound by a vibrating string, a column of air, or the vibration of a diaphragm. In all, five experiments were completed. The individual laboratory work group was able to complete all of these.

The unit on magnetism seemed to have the greatest number of objects that could be held, looked at, or manipulated by the students. Eight experiments were used in this unit and all of these seemed to be easy for

the individual laboratory work group to perform.

The final unit that was studied was one on light. This unit was slightly different from the others in the respect that one experiment was performed by all the students using the individual laboratory work method. The same duplicated instructions and equipment was given to all the classes. This was done in an effort to detect any differences such as preference of method and problem-solving ability between the experimental and control groups. (See Appendix B.)

Discovering attitudes toward method of instruction. After letting the control group experience individual laboratory work, everyone was asked to answer ten questions that had been prepared by the teacher as a poll of their attitudes toward these two methods of instruction. (See Appendix B.)

Discovering differences in problem solving. In an effort to measure any differences in problem solving, an experiment that had not been performed by any of the students was selected. The students were asked to read the instructions and then proceed as best they could in the time allotted. This experiment was concerned with using concave and convex mirrors and making certain observations with them concerning the way in which light was reflected.

CHAPTER IV

TREATMENT OF DATA

To determine whether the differences between the two groups on their final tests were significant and to measure any differences between the two methods of instruction, it was decided to compare the data collected from the results of the final unit tests of the groups by the method of "equivalent groups."¹

I. THE METHOD OF EQUIVALENT GROUPS

Equivalent groups. In the method of equivalent groups, more specifically known as "matching by pairs," each person in the first group was matched with a person in the second group by I. Q., test score, or some other characteristic. This procedure made possible setting off the effects of one or more experimentally varied conditions against the absence of the same variable in the control group.

Matching the groups. The matching here was accomplished in two ways. In the first comparison of final test scores, the intelligence quotients of students in the lecture-demonstration group and the individual laboratory work group were matched. In the second comparison of final test scores, the pretest scores of the students in each group were matched. An attempt was also made to compare the final test scores of those in each group who had the same I. Q. and pretest score. However, this proved to

¹Harry E. Garrett, Statistics in Psychology and Education (fifth edition; New York: Longmans, Green and Company, 1958), p. 228.

be unsatisfactory because of the extremely few cases in which these conditions existed. The people in each group who had exactly the same intelligence quotients, as measured by the Otis Beta Quick Scoring Mental Ability test, were matched first. Those with a variation of one point were then matched and added to the identically matched pairs to make possible as large a sample as could be obtained. Twenty-nine pairs were matched exactly. Twenty-two pairs whose intelligence quotients differed by one point were added. This brought the number of matched pairs to fifty-one out of a possible seventy-seven. One hundred sixty students participated, but some were made ineligible by the limits established earlier. Some students had been absent and had missed the pretest, final test, or I. Q. test.

II. STATISTICAL ANALYSIS OF THE FINAL TEST

SCORES AND MATCHING BY I. Q.

Finding the mean. To begin the comparison of the final scores, based on the matched intelligence quotients of students, the scores of these particular students were assembled. The arithmetic means for the pretest and final test on the first unit were computed. The exact arithmetic means were found by adding the scores and dividing the sum by the number of matched pairs of scores. Garrett's formula² for finding the arithmetic mean of ungrouped data was used. The formula is:

$$M = \frac{\sum X}{N}$$

² Ibid., p. 27.

The mean as used in this study was regarded as a typical or representative point in the distribution around which the rest of the scores seem to cluster, or gather in a distribution not badly skewed.

Finding the standard deviation. The standard deviation on the scores of the final unit tests was next found by calculation of the standard deviation directly from the ungrouped scores. This was done in an attempt to get a measure of the degree of spread of the scores around the mean, and it was needed for future use in finding the standard error of means, the standard error of the difference between the means, and in calculating the critical ratio. The formula used to find the standard deviation was the same as used by Garrett³ for an ungrouped set of data. The formula is:

$$\sigma = \sqrt{\frac{\sum x^2}{N}}$$

The deviations of the separate scores from the exact arithmetic mean were tabulated. Each of these was then squared. The square root of the sum of the squared deviations, divided by the number of matched pairs, (N), yielded the standard deviation for the results of the final test scores.

Finding the standard error. To find the standard error of the means of the final tests, Garrett's⁴ formula for the standard error of the mean was used. It is:

$$SE_m \text{ or } \sigma_m = \frac{\sigma}{\sqrt{N}}$$

³ Ibid., p. 50.

⁴ Ibid., p. 185.

This was computed to help indicate what differences up to the size of sixty-eight chances out of one-hundred could be expected to be due to chance, or to forecast the parameters or limits to which our statistics here, the sample means, spread or cluster around the fixed population mean. It could also be thought of as a measure of the stability or trustworthiness of a sample mean, as the standard deviation of a distribution of sample means around the fixed mean of a population, or as a measure of the amount by which the sample means diverge from the over-all population mean.

Finding the correlation. The correlation (r) between the final test scores was then found by the "difference formula method."⁵ The difference formula is:

$$r = \frac{\sum x^2 + \sum y^2 - \sum d^2}{2 \sqrt{\sum x^2 \cdot \sum y^2}}$$

The correlation found was the correlation between the matched pairs of the final scores of the lecture-demonstration and individual laboratory work groups, matched in terms of intelligence quotients. This formula was employed so that no cross-products needed to be computed. The deviations from the actual means that had already been found for calculation of the standard deviations were used. The difference of these deviations of the two groups were then found by subtracting algebraically each (Y) deviation from its corresponding (X) deviation. These differences were then squared and entered in the (d^2) column where they were added and substituted into the formula already given.

⁵Ibid., p. 145.

The standard error. The standard error of the difference between the means on the final test could then be found by using the following:⁶

$$\sigma_D = \sqrt{\sigma_{m_1}^2 + \sigma_{m_2}^2 - 2r \sigma_{m_1} \sigma_{m_2}}$$

This was done to measure the degree of spread of the scores around the population means.

The critical ratio. The difference found was tested by the "t" ratio, or critical ratio⁷ formula shown below.

$$C. R. = \frac{M_1 - M_2}{SE_d}$$

Table D⁸ was then used to determine whether the value found for the critical ratio was significant or not. This table contained the limits that this difference could occur by chance 68, 90, 95, 98, or 99 times out of 100.

Presentation of data. The relevant data of the six units studied, where the matching was accomplished by I. Q. scores, are presented in Table I., p. 22.

Summation of findings when groups were matched by I. Q. The critical ratio of the unit on water was the only one out of the six studied that was found to be significant at the .05 level. While there was a

⁶Ibid., p. 228.

⁷Ibid., p. 215.

⁸Ibid., p. 449.

TABLE I
THE CRITICAL RATIO OF INITIAL AND FINAL TEST SCORES
WHEN THE MATCHING IS DONE BY I.Q.

UNIT Group*	FIRE		WATER		WEATHER		SOUND		LIGHT		MAGNETISM	
	(X)	(Y)	(X)	(Y)	(X)	(Y)	(X)	(Y)	(X)	(Y)	(X)	(Y)
Number of matched pairs	51	51	51	51	51	51	51	51	51	51	51	51
M's from pretests	5.24	4.88	16.51	16.21	17.24	18.47	16.25	17.24	18.68	17.98	14.50	12.82
M's from final tests	35.75	36.96	32.76	35.08	33.60	34.96	38.20	39.90	16.0	18.5	32.37	31.58
S.D. on final tests	9.69	8.54	7.32	5.79	8.43	7.48	6.32	5.49	3.90	4.84	4.71	5.40
Gain ($M_2 - M_1$) M's of final test	1.21		2.31		1.36		1.70		2.50		-.79	1.76
SE _m , final tests	1.36	1.19	1.03	.81	1.18	1.05	.885	.768	.55	.68	.659	.756
Correlation between final scores matched by I.Q.	.73		.79		.73		.63		.69		.68	
SE _d	.95		.63		.83		.72		.50		.53	
C.R.	1.27		3.67		1.14		1.15		1.88		1.49	
level of significance	>.10		.01		>.10		>.10		.10		>.10	

* M_1 = (X) = controlled or Lecture-demonstration Group.
 M_2 = (Y) = experimental or Laboratory Work Group.

slight gain made in each unit by the laboratory work group, in only one instance does the gain seem to be large enough that one may feel reasonably certain that the individual laboratory work method had a significant effect in stimulating the performance of these seventh grade science students. Moreover, the means of the pretest scores were not as close as had been hoped and might indicate that the pairing of scores by intelligence quotients was not as satisfactory as it might have been.

III. STATISTICAL ANALYSIS OF FINAL TEST SCORES AND MATCHING BY EXACT PRETEST SCORES

In an attempt to avoid marking a significant finding not significant, or a non-significant finding as being significant, the method of equivalent groups was used again. However, in this instance, the method pairs were matched in terms of the exact pretest score. It was believed that the pretest scores in this study were due to background more than intelligence quotient. These scores were then subjected to the same procedure used before.

Matching in units. For the first unit, fifty-six pairs out of a possible seventy-seven were paired child for child by the scores they received on the first pretest. In selecting the pairs, all of the pupils in the lecture-demonstration group were listed along with their pretest score. These were then matched with as many members of the other group as possible. This rematching was repeated for each unit studied. The results are presented in Table II., p. 24.

Summation of findings when groups were matched by pretest score.
The data collected in this comparison seemed to indicate that there may

TABLE II
THE CRITICAL RATIO OF INITIAL AND FINAL TESTS SCORES
WHEN THE MATCHING IS DONE BY PRETEST SCORE

UNIT Group*	FIRE		WATER		WEATHER		SOUND		LIGHT		MAGNETISM	
	(X)	(Y)	(X)	(Y)	(X)	(Y)	(X)	(Y)	(X)	(Y)	(X)	(Y)
Pairs of children	56	56	57	57	52	52	47	47	52	52	52	52
M's from pretests	4.9	4.9	16.21	16.21	16.5	16.5	16.49	16.49	8.43	8.43	13.27	13.27
M's from final tests	32.59	37.66	30.0	35.35	32.3	34.6	37.8	38.8	14.8	18.2	31.32	31.94
S.D. on final tests	10.07	8.2	7.8	5.5	9.1	7.6	6.2	5.6	3.8	3.4	5.04	4.70
Gain ($M_2 - M_1$) M's of final test	5.07		5.35		2.3		1.0		3.4		.62	24
SE _m final test	1.34	1.09	1.04	.73	1.26	1.06	.91	.83	.53	.47	.70	.65
Correlation between final scores matched by pretest		.65		.56		.68		.83		.75		.69
SE _d		1.03		1.23		.94		.50		.357		.53
C.R.		4.92		4.35		2.44		1.98		9.50		1.17
level of significance		.01		.01		.02		.05		.01		> .10

* M_1 = (X) = control or Lecture-demonstration Group.
 M_2 = (Y) = experimental or Laboratory Work Group.

have been a significant gain not due to chance in five of the six units of study. This was quite different from the results received from the comparison of final scores when the matching was done by matching intelligence quotients. However, one might recall that the data of Table I indicated an increase in the mean of the final test scores of the laboratory work group in all but the last unit of study. These gains, however, were not great enough to be significant at the .05 or .01 levels except for one unit, the unit on water. Therefore, the other gains could not be said to be due to anything except chance.

Discovering pupil preference of laboratory method. In an effort to measure or determine the pupils' preferences of the laboratory method employed, the laboratory work group and the lecture-demonstration group were given an opportunity to express their preferences by answering ten yes and no questions prepared by the teacher. (See Appendix B.) These questions, it was hoped, would reveal the students' preferences and attitudes pertaining to the method of laboratory work that they liked most, whether they liked doing laboratory work, what kind of instructions they preferred, and under which method they worked the hardest and best understood the material presented. The compiled results of the questionnaire are presented in Table III., p. 26.

Discovering differences in problem solving. In an effort to measure differences in resourcefulness at solving a laboratory problem, an experiment which had not been done in class before was selected. (See Appendix B, Part II.) This experiment was concerned with using concave and convex mirrors and making certain observations concerning the way in which light is reflected. This experiment did not appear in the regular

TABLE III
PREFERENCES OF LABORATORY METHOD EMPLOYED

Questions:	INDIVIDUAL LABORATORY WORK GROUP		LECTURE DEMONSTRATION GROUP	
	Per cent who answered	Per cent who answered	Per cent who answered	Per cent who answered
	Yes	No	Yes	No
1. Do you enjoy doing laboratory work more than watching the experiment being performed by the teacher?	64	36	71	29
2. Do you understand the experiment better when the teacher does it than when you do it yourself?	70	30	72	28
3. Do you prefer to have the teacher do all the experiments or demonstrations?	35	65	36	66
4. Do you prefer to have all individual laboratory work.	27	73	34	66
5. Do you think that you could learn as much from a similar course with no accompanying laboratory work?	12	88	8	92
6. Do you think that having individual laboratory work encourages you to work harder?	74	26	76	24
7. Do you think that having individual laboratory work helped increase your interest in science?	78	22	81	19
8. Do you think that individual laboratory work helped you to remember the facts?	83	17	80	20
9. Do you think that waiting to do the experiment is too tiring?	30	70	28	72
10. Do you prefer written to oral instructions?	41	59	42	58

N = 160

textbook and it is not likely that anyone had the occasion to familiarize themselves with this information. Some suggestions for an exercise similar to the one used appear in the UNESCO Source Book for Science Teaching.⁹ The students were asked to demonstrate by drawing illustrations or by telling the examiner orally how they would proceed to do the experiment. By their illustrations or verbal replies, the examiner, their teacher, decided whether they had successfully completed the experiment. The following data were collected and tabulated as shown in Table IV., p. 28.

IV. STATISTICAL ANALYSIS OF THE PERCENT OF SUCCESSSES IN PROBLEM SOLVING

The total per cent of successes in the laboratory work group was slightly greater than the total per cent of successses in the lecture-demonstration group. In an effort to determine whether this increase was significant or not, the standard error of the percentage was computed by the equation used by Garrett¹⁰ which follows:

$$\sigma\% = \sqrt{\frac{P Q}{N}}$$

"P" is the per cent occurrence of the behavior, "Q" is (1-P), and N is the size of the sample. To estimate "P", one must pool $P_1 = 75\%$ and $P_2 = 64\%$. A pooled estimate of P was obtained from the equation below¹¹

$$P = \frac{N_1 P_1 + N_2 P_2}{N_1 + N_2}$$

⁹UNESCO Source Book for Science Teaching (United Nations Educational Scientific and Cultural Organization, Paris: 1959), p. 177.

¹⁰Garrett, op. cit., p. 235.

¹¹Ibid., p. 235.

TABLE IV
DIFFERENCES IN PROBLEM SOLVING
ON ONE EXPERIMENT

Science Class Section Number	Number of Pupils in Class	Successes	Failures	Per Cent of Successes
s - 1 (Y)*	27	23	4	85
s - 2 (X)	25	18	7	72
s - 3 (X)	30	25	5	83
s - 4 (Y)	24	12	12	50
s - 5 (X)	26	18	8	70
s - 9 (Y)	28	16	12	57
	<u>N = 160</u>			

Total Per Cent of Successes in laboratory work group (X) = 75%

Total Per Cent of Successes in lecture-demonstration group (Y) = 64%

*(Y) = control group.

(X) = Experimental group.

Once P has been found, the SE of the difference between these two percentages was found by substituting P and Q into the following:¹²

$$SE_{d\%} = \sqrt{PQ \left[\frac{1}{N_1} + \frac{1}{N_2} \right]}$$

The critical ratio was then found. The formula is¹³:

$$C. R. = \frac{(P_1 - P_2) - 0}{SE_{d\%}}$$

A critical ratio of 1.52 was found. Using Table D¹⁴, the indication was that this value was not significant at the .10 level and one could not say a true difference existed between these two groups that was not due to chance.

¹² Ibid., p. 236.

¹³ Ibid., p. 236.

¹⁴ Table D., p. 449.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary. The objectives of this study were to determine whether there were any measurable outcomes of individual laboratory work in a seventh grade course of general science at one junior high school in Montana, and to suggest in part, how this junior high school could utilize its resources to the best advantage. In addition, an attempt was made to suggest some of the preferences these students had concerning the method by which the laboratory work was carried on, and whether one method or the other had any effect on the students' ability or resourcefulness in solving a new laboratory problem.

Conclusions. The results of the data gathered by matching the students according to intelligence quotient revealed that there was a slight gain made by the laboratory work group to the extent that the mean of their final test scores was increased slightly in five out of the six units studied. However, in only one unit was the gain made by the laboratory work group significantly higher. In a similar problem of comparing initial and final test scores, Garrett¹ points out that "The means and standard deviations of the control and experimental groups. . . are almost identical, showing the original pairing of scores to have been quite satisfactory." In the problem at hand, it was found that the means and standard deviations varied considerably which might indicate that matching the

¹Garrett, op. cit., p. 229.

groups by intelligence quotient did not furnish the necessary control for selection of the matched pairs.

In an attempt to correct this situation, the students were matched by the pretest scores they received at the beginning of each unit of study. The exact pretest score was used and the matched pairs were selected for each unit on this basis. The results of this data seemed to indicate a slight gain made by the laboratory work method group in all of the units studied. The critical ratios were great enough in five of the six units to indicate the differences between the final test scores of the two groups were significant at the .05 level of significance or less and therefore probably not due to chance. (See Table II.), p. 24.

Of additional interest was the survey of student attitudes and preferences concerning the two methods of laboratory instruction. (See Table III.) A majority of the students from both groups seemed to be either for or against a particular situation given. In no case was there a disagreement between the students of either group. The majority of students agreed on the following:

- (1) They enjoyed doing the laboratory work more than just watching someone else do it.
- (2) They understood the experiment better when the teacher did it.
- (3) Individual laboratory work encouraged them to work harder.
- (4) Individual laboratory work helped increase their interest in science.
- (5) Individual laboratory work helped them in learning and remembering the facts.
- (6) They believed laboratory work was necessary part of the learning situation.

- (7) They did not prefer to have the teacher do all the experiments or demonstrations.
- (8) They did not want to do them all themselves.
- (9) They did not mind waiting to use the equipment.

The most controversial question seemed to be whether or not they preferred following written rather than oral instructions. The majority indicated that they liked oral instructions rather than written instructions. This finding seems to support a statement made by J. L. Coopriders² who said "exercises with oral instructions give better results than exercises with written instructions in both demonstration and individual work." It also supports the statement of Mayman³ to the effect that "as regards elementary science, elementary school pupils cannot get the thought of the printed page."

The results of the data indicating success or failure to solve a new laboratory exercise or experiment, indicated that the laboratory work group was slightly but not significantly more successful. (See Table IV.) Seventy-five per cent of the laboratory work group was successful in comparison to sixty-four per cent of the members of the lecture-demonstration group. However, this difference was not significant and it appeared that the previous work or practice in doing individual laboratory work by that group had very little or no effect on the increased percentage of

²Coopriders, op. cit., p. 844.

³Jacob Edward Mayman, An Experimental Investigation of the Book Method, Lecture Method, and Experimental Method of Teaching Elementary Science in the Elementary Schools. Doctor's Thesis (New York: NYC of Educational Research, 1912).

successes that were reported.

It was also observed that in experiments that run from day to day, the students seemed to take more interest in making the observations if they had been the active agents in setting up the experiment. If their minds were cluttered with the details of procedure, they seemed to be unable to consider results carefully or give complete explanations.

In addition to the survey of student attitudes and preferences mentioned on pages thirty-one and thirty-two, the conclusions of this experimental study in a seventh grade course of general science at West Junior High School, Great Falls, Montana, appeared to be:

- (1) A slight but not significant gain seemed to be made in performance on teacher-made objective final unit tests by those engaged in individual laboratory work.
- (2) The students seemed to enjoy the extra activity and manipulation of materials.
- (3) Resourcefulness in solving new laboratory exercises seemed to be not significantly increased by practice and familiarization with the tools and methods of problem solving.
- (4) There was probably not as great a difference between these two methods as might ordinarily be supposed.
- (5) The ability to solve problems independently and to develop laboratory skills were delayed results which could not be measured at the present time.
- (6) The choice of science as a career and the cultivation of an interest in the processes of inquiry were outcomes that presently could not be measured.
- (7) Individual laboratory work at this grade level seemed to do no harm and may even have helped the students in some way.

Recommendations. These findings seemed to indicate that the best method of laboratory instruction for West Junior High School and for the teacher involved would be a combination of the individual laboratory work

method and the lecture-demonstration method. By making some provision for individual laboratory work to be done, a gain might be made in student satisfaction and teacher effectiveness. By making only a few of the easier experiments laboratory work, one could satisfy those who did not desire to do all the experiments themselves. The need for further study in this area is indicated, it seemed, by the almost total absence of related literature in this field for this particular grade level. The writer would hasten to add that this work is in no sense final and that no results or conclusions should be considered as more than suggestive. The final conclusions must be based on much more work of a similar nature, under better controlled conditions, in other schools, under other teachers, working with other groups across the country.

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APPENDIX A
PRETESTS AND FINAL TESTS
UNITS 1 THROUGH 6

1. The heat necessary to light a match is produced by (light, friction, abrasion).
2. The lowest temperature at which a fuel will burn and continue to burn is known as the (oxidation temperature, kindling temperature, boiling temperature).
3. Any substance which gives off light and heat when burned is called (matter, a fuel, an element).
4. The gas in the air which is necessary for burning is called (O_2 , N, CO_2).
5. The combining of a fuel with oxygen in which heat and light are produced is called (oxidation, combination, respiration).
6. The combining of any substance with oxygen is called (oxidation, combination, respiration).
7. The gas formed when carbon burns in air is called (O_2 , N, CO_2).
8. The gas or vapor formed when hydrogen burns in air is known as (water vapor, H_2O , CO_2).
9. The gas which will turn limewater milky white is (H_2O , CO_2 , N).
10. A fire caused by slow oxidation in places where the heat cannot escape is known as (spontaneous combustion, an explosion, radiation).
11. The process of changing a vapor to a liquid is called (condensation, evaporation, precipitation).
12. The process of changing a vapor to a liquid, then to a vapor is called (a water cycle, a gas cycle, an air cycle).
13. The black substance formed when bread is burned is known as (ash, carbon, coal).
14. The name of the kind of coal formed under great pressure is (bituminous, lignite, anthracite).
15. The kind of coal heated in a test tube to make coke is (bituminous, lignite, anthracite).
16. If wood is heated in a closed test tube, the product left in the tube is called (charcoal, coke, ash).
17. The reddish-brown substance formed when iron is left in air is (rust, dirt, steel).
18. A low grade of coal formed without requiring much pressure is known as (bituminous, lignite, anthracite).

19. If a fuel is heated to its kindling temperature and continues to burn, it must have (O_2 , CO_2 , H_2).
20. The substance that may be added to a fire to cool it below its kindling temperature is (water, air, wood).
21. Which of the following are necessary for a fire? (O_2 , CO_2 , H_2 , N wood, coal, a fuel, heat, kindling temperature, smoke, light, a stove.) ,
24. Fuels are made of (wood, coal, carbon, nitrogen, smoke).
25. Three ways in which fires may be put out are (remove the fuel, lower the temperature, remove the air).
28. The three products of combustion of common fuels are (O_2 , CO_2 , H_2 , water vapor, heat, light, smoke).
31. Three characteristics of a good fuel are (cheap, produces much light, produces much heat, burns slow, burns fast, easy to transport).
- 34-36. How was coal formed?
37. Iron rusting is an example of (slow, fast, neither) oxidation.
38. Slow oxidation is another name for (spontaneous combustion, chemical reaction, the kindling temperature).
39. Matches contain the substance (O_2 , phosphorus, carbon) to get them started to burn.
40. Charcoal is made by heating (wood, coal, oil).

FINAL TEST UNIT 2, FIRE

I. Multiple Choice. Choose the most correct response. Place the letter of the response in the space in the margin.

- _____ 1. The first match was invented in England in (A) 1775 (B) 1898 (C) 1827 (D) 1910.
- _____ 2. The substance in the head of a match that starts burning at a low temperature is usually some form of (A) magnesium (B) phosphorus (C) oxygen (D) carbon.
- _____ 3. Which of the following has the lowest kindling temperature? (A) wood (B) paper (C) coal (D) oil.
- _____ 4. Approximately (A) $2\frac{1}{4}$ (B) $\frac{1}{5}$ (C) $\frac{1}{3}$ (D) $\frac{1}{2}$ of the air is oxygen.
- _____ 5. The greatest percentage of the air is mostly (A) carbon dioxide (B) water vapor (C) carbon monoxide (D) nitrogen.
- _____ 6. Which of the following is used as a test for carbon dioxide? (A) limewater (B) hydrochloric acid (C) paraffin (D) potassium chlorate.
- _____ 7. In making oxygen which of the following was used as a catalyst? (A) potassium chlorate (B) manganese dioxide (C) mercuric oxide (D) hydrochloric acid.
- _____ 8. Charcoal is made by heating which of the following materials? (A) lignite (B) bituminous coal (C) wood (D) anthracite coal.
- _____ 9. Which of the three kinds of coal burns most slowly? (A) bituminous (B) anthracite (C) lignite.
- _____ 10. When substances combine with oxygen we call the process (A) combustion (B) burning (C) oxidation.
- _____ 11. Oxygen was made in class by heating (A) potassium chloride (B) potassium chlorate (C) mercury (D) burning wood.
- _____ 12. Which of the following compounds are formed when magnesium is burned? (A) MgO^2 (B) MgO (C) FeO^2 (D) FeO .
- _____ 13. Which of the following compounds are formed when iron rusts? (A) MgO^2 (B) MgO (C) FeO^2 (D) FeO .

- ____14. Which of the following materials is not formed when a paraffin candle burns? (A) carbon dioxide (B) nitrogen (C) carbon (D) water vapor.
- ____15. Which of the following is a poisonous gas that is formed when fuel burns without enough oxygen? (A) nitrous oxide (B) ammonia gas (C) carbon monoxide (D) carbon dioxide.
- ____16. Which of the following kinds of extinguishers should never be used to put out a grease fire? (A) carbon tetrachloride (B) foam (C) water (D) carbon dioxide.
- ____17. Which of the following kinds of extinguishers should never be used to put out an electrical fire? (A) water (B) carbon tetrachloride (C) carbon dioxide.
- ____18. Coke is made by heating which of the following materials in large ovens? (A) wood (B) bituminous coal (C) lignite (D) anthracite coal.

II. Fill in the blanks with the proper response. Place your answers in the left hand margin that correspond with numbered blanks in each sentence.

- _____ 1. When you rub two sticks together you produce heat by 1.
- _____ 2. A 2 is any substance that will burn and give off heat.
- _____ 3. When any material burns it combines with the 3 in the air.
- _____ 4. In order to start a fire the material you want to burn must be heated to its 4 temperature.
- _____ 5. When a material burns we call this 5 oxidation.
- _____ 6. When iron rusts we call this 6 oxidation.
- _____ 7. The black material that is left over when materials such as wood, paper and cloth have been burned is a chemical known as 7.
- _____ 8. When hydrogen is burned it forms 8.
- _____ 9. Hydrogen gas was made in class by pouring 9 acid over
- _____ 10. 10.

III. Matching. Match the items on the right with the items on the left. Use the letters.

- | | |
|---------------------------------|---|
| _____ 1. rust | a. A fuel made from wood by heating it in the absence of air. |
| _____ 2. anthracite | b. Iron oxide |
| _____ 3. bituminous | c. Fire |
| _____ 4. charcoal | d. A fuel made by heating soft coal in the absence of air. |
| _____ 5. coke | e. A substance that will burn. |
| _____ 6. combustion | f. A low-grade form of coal. |
| _____ 7. lignite | g. The combining of a substance with oxygen. |
| _____ 8. oxidation | h. Soft coal. |
| _____ 9. spontaneous combustion | j. The slow oxidation of a substance until there is enough heat to cause the substance to burst into flame. |
| _____ 10. fuel | |

IV. Recall. Place your answers in the spaces provided in front of the question.

- _____ 1. What gas in the air is necessary for burning?
- _____ 2. What is the black substance formed when most materials are burned?
- _____ 3. What highly explosive material is found in most fuels?
- _____ 4. What material is a fire being deprived of if it gives off a great deal of smoke?
- _____ 5. What three things are necessary for a fire?
- _____ 6. What product of combustion are you testing for when you lower a beaker open and down over a candle flame?

V. Answer the three questions of the next page briefly.

1. In what three ways may fires be put out?
2. Explain why water does not put out a kerosene, gasoline or grease fire.
3. Why is water dangerous to use on an electrical fire?

PRETEST 2, UNIT 3, WATER

1. The process of changing a gas to a liquid is known as (condensation, evaporation, radiation).
2. The process of changing a liquid to a gas is called (condensation, evaporation, radiation).
3. The process of changing a liquid to a gas and back to a liquid again is called the (food, the water cycle, life cycle).
4. The amount of moisture in the air is known as (rain, fog, humidity).
5. The spraying of water into the air to remove unpleasant tastes and odors and add air to the water is known as (chlorination, purification, aeration).
6. A series of events that follow each other and may be repeated is known as a (plan plot, event, cycle).
7. The removal of solid materials by letting the water stand still for some time is called (condensing, settling, aeration).
8. The process of removing solid materials from water by passing it through sand, paper, or cloth is called (settling, aeration, filtering).
9. The uppermost level of water in the soil is called the (top soil, bed rock, water level, water table).
10. The kind of matter, found in water, which is living or has lived is said to be (organic, inorganic, foreign, chemical) matter.

TRUE OR FALSE

11. The rate of evaporation of a liquid is increased by heating it.
12. The temperature of a liquid is increased by heating it.
13. A liquid will evaporate faster in a container if the container is covered.
14. A liquid evaporates faster if air is forced over it rapidly.
15. A liquid will evaporate faster in a small dish than in a large one.

16. Alcohol evaporates faster than water under the same temperature.
17. Warm air cannot hold as much water as cold air.
18. When a liquid evaporates, heat is absorbed.
19. When water vapor condenses, heat is set free.
20. Dew collects on grass at night if the water vapor is cooled to the dew point.
21. You feel more comfortable on hot days when the humidity is high.
22. Dry air is heavier than air which has a high humidity.
23. When air and water vapor rise to the cold, upper atmosphere, the water vapor condenses.
24. All water obtained from wells is pure .
25. Chlorine gas is added to drinking water to remove the minerals.
26. The largest part of fruits and vegetables is water.
27. Water is safe for drinking purposes if it does not contain any air.
28. The flat taste of water is caused by a lack of minerals.
29. In distillation, the minerals are separated from the water.
30. You feel warmer if the rate of evaporation of perspiration from your body is increased.

FINAL TEST UNIT 3, WATER

Put in the blank space to the right of each item in column B the letter of the matching item in column A.

COLUMN A	COLUMN B
A. Aeration	1. A series of events which follow each other and may be repeated. _____
B. Boiling	2. The uppermost level of water in the soil. _____
C. Condensation	3. The kind of matter which is living or which was once living. _____
D. Cycle	

- | | |
|------------------|---|
| E. Distillation | 4. The amount of moisture in the air.____ |
| F. Evaporation | 5. The process of changing a liquid into a vapor and back to a liquid. ____ |
| G. Filtering | 6. The spraying of water into the air to remove unpleasant tastes or odors. _____ |
| H. Humidity | |
| I. Inorganic | 7. The process of removing solid materials from water by passing it through paper, cloth, or a sand. ____ |
| J. Organic | |
| K. Precipitation | 8. The process of removing solid materials from water by letting it stand for some time. |
| L. Settling | |
| M. Water Table | 9. The changing of a gas to a liquid. ____ |
| | 10. The changing of a liquid to a vapor.____ |

TRUE OR FALSE:

11. Alcohol evaporates faster than water if both are kept under the same conditions.____
 12. Cold air can hold less water vapor than warm air.____
 13. The temperature of alcohol gets lower as it evaporates.____
 14. The rate of evaporation is increased by raising the temperature.____
 15. The rate of evaporation of water is increased by decreasing the size of the dish which holds the water.____
 16. A liquid in a dish will evaporate faster if the dish is kept covered.
 17. When a liquid evaporates, heat is absorbed.____
 18. Water vapor condenses when it is heated.____
 19. Dry air is heavier than air which has a high humidity.____
 20. Moisture in the air will condense if it is cooled to the dew point.____
- After each of the following, write a sentence giving the fact or facts which prove the statement is correct.
21. Chlorine is added to drinking water to purify it. Why?

22. Clothes dry better on a windy day. Why?
23. You feel uncomfortable on a warm humid day. Why?
24. Your hand feels cool when you put a few drops of alcohol on it. Why?
25. Impurities are separated from water by distilling it. Why?
26. Boiled water tastes flat. Why?
27. Liquids are used to cool foods in the electric refrigerator. How?
28. What are the two major steps in the water cycle?
29. What are the two principal sources of our cities' water supplies?
30. How can you find out the percentage of water in fruits by an experiment?
31. What is Matter?
32. In what three forms does matter exist?
33. What two conditions help liquids evaporate?
34. Ammonia is no longer used in household refrigerators because (A) it is too expensive (B) it is poisonous (C) it burns (D) it mixes with air and explodes.
35. The boiling point of a liquid can be lowered by decreasing the (A) temperature (B) heat (C) air pressure (D) steam pressure.
36. How is water vapor added to the air by plants?
37. How is water vapor added to the air by animals?
38. How is water vapor added to the air by fires?
39. How is water vapor added to the air by oceans?
40. How is water added to the air by automobile engines?
- 41.-43. What three things does the molecular theory tell us about molecules?
44. How does heating and cooling change the volume of materials?
45. What is the melting point of a material?
46. Name a solid that evaporates without melting?

47. Explain why there is no salt in rain water even though most of our rain comes from water that once was in the salty ocean.
48. What effect does freezing have on the molecules of a material?
49. During evaporation of water, what happens to the molecules of that material?
50. Make a drawing showing the water cycle. Be sure to label each step.

PRETEST 3, UNIT 4, WEATHER

1. The instrument used to measure temperature is the (barometer, aerometer, thermometer).
2. The instrument used to measure air pressure is the (barometer, aerometer, thermometer).
3. The instrument used to measure the velocity of the wind is the (barometer, aerometer, thermometer).
4. The changing conditions of the air for a short time is known as (weather, climate, season, equinox).
5. The average conditions of the air over a long period of time is known as (weather, climate, season, equinox).
6. Air in motion is called a (storm, calm, front, wind).
7. The distance above the ground or sea level is known as (elevation, summit, latitude, longitude).
8. The temperature at which the water vapor begins to condense is called the (kindling temperature, boiling temperature, freezing point, dew point).
9. The blowing of the air from the water to the land is called a (land breeze, sea breeze, chinook wind).
10. The blowing of the wind from the land toward the water is called the (land breeze, sea breeze, chinook breeze).
11. Rapid motion of the air due to sudden changes in temperature and humidity is called a (storm, calm, front, wind).
12. The instrument used to measure the humidity in the air is the (barometer, hygrometer, anemometer).

TRUE OR FALSE:

13. Air expands when heated.

14. Water expands when heated.
15. Cold air rises.
16. Air contracts when cooled.
17. Water vapor condenses when air is heated.
18. Warm air can hold more water vapor than cold air.
19. Dry air is heavier than humid air.
20. Dry air is heavier than cold air.
21. The barometer reading is high when the air is cold and dry.
22. Frost is formed if the dew point is below the freezing temperature.
23. When the dew point in a cloud is reached, it will rain.
24. Air becomes cooler when it expands.
25. A low barometer reading indicates stormy weather.
26. Cirrus clouds indicate fair weather.
27. Soil will heat up faster in the sun than water.
28. Soil will cool off faster than water.
29. Cumulus clouds usually bring rain.
30. Mercury is used in a thermometer because it will not easily freeze.
31. All thermometers contain mercury.
32. We live in a tropical climate.
33. Air above the earth is very cold.
34. In space there is no air.
35. Clouds are made of smoke from factories.
36. Air pressure is represented on a weather map by dots and dashes.
37. The speed of the wind is shown by an arrow.
38. Cloud type is shown by dots and dashes.

39. Cloudiness is represented by shaded circles.

40. Cloud type is shown by dots and dashes.

FINAL TEST UNIT 4, WEATHER

DIRECTIONS: Write in the blank space at the right of each item in column B the letter of the matching item in column A.

COLUMN A

COLUMN B

- | | |
|----------------------|--|
| A. Carbon dioxide | 1. The gas in the air most important to life. _____ |
| B. Climate | 2. Weight per unit volume of a substance. _____ |
| C. Density | 3. The amount of moisture in the air. _____ |
| D. Fossils | 4. The condition of the air at one particular time. _____ |
| E. Geologist | 5. The average conditions of the air at one certain place. _____ |
| F. Geology | 6. Air which holds all the moisture it can at a given temperature. _____ |
| G. Humidity | 7. Type of climate found in Florida. _____ |
| H. Marine west coast | 8. Type of climate found in Seattle, Washington. _____ |
| I. Mediterranean | 9. One who studies the formation of the earth. _____ |
| J. Oxygen | 10. Forms of plants or animals preserved in the earth. _____ |
| K. Pollen | |
| L. Rain | |
| M. Saturated | |
| N. Sun tropical | |
| O. Weather | |

II. Complete the following statements by putting the best word or words in the spaces to the right.

11. The most abundant gas in the air is _____.
12. A change in the temperature of the air changes its _____.

13. Air in motion causes_____.
14. In describing climate, the word which is often used is_____.
- 15-17. Three factors which affect climate are_____.
18. When saturated air is cooled, it loses some of its moisture in the form of_____.
19. The type of climate you have where you live is_____.
20. Scientists prove the climate of the West Coast has changed by studying_____.
21. When solids absorb radiant energy, they are (A) cooled (B) heated (C) illuminated. _____
22. Slanting rays from the sun produce (A) more heat (B) more light (C) less heat than direct rays. _____
23. Direct rays from the sun hit the U. S. (A) in the summer (B) in the winter (C) neither of these. _____
24. A cubic foot of warm air contains (A) fewer molecules than a cubic foot of cold air (B) more molecules (C) the same number of molecules as a cubic foot of cold air. _____
25. An increase in the amount of moisture in the air (A) decreases (B) increases (C) does not affect its density. _____
26. Most of the time our winds are from the (A) north (B) west (C) south. _____
27. When it comes to absorbing and losing heat: (A) water takes longer than the earth (B) the earth takes longer than water (C) air takes longer than either. _____
28. The western slopes of the Rocky Mountains, have (A) average (B) light (C) heavy rainfall. _____
29. Scientists believe the climates of the earth are (A) staying the same (B) becoming cooler (C) becoming warmer. _____
30. When water vapor is added to the air (A) the density of air is increased (B) decreased (C) remains unchanged. _____
31. When water vapor is added to air, the humid air becomes (A) heavier (B) lighter (C) cooler. _____
32. When air is heated, does it (A) contract (B) expand (C) rise (D) fall. _____

33. When the air is cooled several degrees, the water vapor (A) evaporates (B) cools (C) condenses. _____
34. When air is heated, will it hold (A) more (B) less (C) the same amount of water vapor. _____
35. Draw a diagram for the following weather stations: (A) Great Falls - clear, wind from the north at 20 knots, temperature 38. (B) Seattle - cloudy, wind from the west at 15 knots, temperature 45, dew point 35, barometer rising, and air pressure 24.7. LABEL AND EXPLAIN ALL YOUR DIAGRAMS....
36. Draw a cross section of a cold front. Indicate the direction of the air flow, the cloud types present, the temperature that would exist on both sides of the front.
37. Draw a diagram and show why moist humid air is lighter than dry air.
38. Draw a diagram and show how water vapor is squeezed out of the air by cooling the air.
39. Draw a diagram and show why more rain falls on the western slope of the Rocky Mountains.
40. What four things does the molecular theory tell us about molecules.
1.
2.
3.
4.
41. Diagram the air movements of a high and a low pressure cell, and explain why each moves as it does. Also indicate which is warm air and which is cold air.
42. A cold front is moving eastward. It is now located over Glendive, Montana. Give the weather forecast for Great Falls, Glendive, and Bismarck, North Dakota.

PRETEST 4, UNIT 6, SOUND

Underline the best response to the following statements.

1. A sound is produced when something is set in____. (a vacuum, pitch, motion)
2. A substance that will spring back when stretched is said to be____. (elastic, pleasing, synthetic)
3. The number of sound vibrations per second is called____. (frequency, pitch, motion)
4. The highness or lowness of sound is called____. (frequency, pitch, motion)
5. Sounds travel through air in the form of____. (waves, vibrations, motions)
6. The membrane in the ear that picks up the vibrations of the air is the____. (eardrum, anvil, hammer)
7. Sounds will not pass through a____. (vacuum, echo, room)
8. The instrument used by cheerleaders in sending more sound in one direction is the____. (microphone, megaphone, telephone)
9. A sound heard by reflection is called____. (an echo, a reflection, a refraction)
10. The number of feet sound will travel in air in one second is____. (100, 500, 1100)
11. Sounds which are pleasant to the ear are said to be____. (pleasing, noise)
12. Sounds that are not pleasing to the ear are called____. (pleasing, noise)
13. In wind instruments, sounds are produced by setting air in____. (columns, motion)
14. The loudness of sound in musical instruments is increased by using____. (sound boxes, more air, microphones)
15. Pipe organs use a different pipe for each____. (sound, pitch, note)
16. The three ways in which wires may be set in vibration are____,
17._____, and 18._____.

TRUE OR FALSE:

19. The length of wires in a violin is changed by using the fingers.
20. Different notes are produced in pipes or tubes by changing the length of the air column.
21. Pitch may be changed by changing the diameter of a wire.
22. Soft surfaces reflect sound to make an echo.
23. Sound waves travel from a vibrating object in only one direction.
24. Sound travel faster in water than in air.
25. Sounds travel faster in water then in steel.
26. Sound waves must have some form of material to carry them.
27. Sound waves will travel through air for one mile in one second.
28. A tight wire vibrates faster than a loose one.
29. A long wire vibrates faster than a small wire.
30. A large wire vibrates faster than a small wire.
31. The pitch of a column of air is raised by increasing the length of the column.
32. Persons can do more work when a room is noisy.
33. Echoes are reduced in a room by covering the walls with curtains.
34. Sounds which have regular rates of vibration are pleasing to the ear.
35. The loudness of a sound can be increased by making a larger volume of air vibrate.
36. The wires on a guitar are set in vibration by bowing.
37. A piano has a wire for each different note.
38. Pipes in an organ may be open at one end or open at both ends.

FINAL TEST UNIT 6, SOUND

Put in the blank space to the right of each item in column B the letter of the matching item in column A.

COLUMN A	COLUMN B
A. Compression	1. The number of sound vibrations per second. _____
B. Discord	2. A sound heard by reflection. _____
C. Echo	3. Sounds which are pleasing to the ear. _____
D. Elastic	4. The highness or lowness of sound. _____
E. Frequency	5. Sounds that are not pleasing to the ear. _____
F. Loudness	6. A movement back and forth. _____
G. Megaphone	7. The part of a sound wave in which particles of air are pushed together. _____
H. Music	8. The kind of a substance that will spring back when stretched or bent. _____
I. Noise	9. A space through which sound waves cannot be carried. _____
J. Pitch	10. One of three bones of the middle ear. _____
K. Rarefaction	11. The part of the wave in which particles of air are spread apart. _____
L. Vacuum	12. Something that turns back sound or light. _____
M. Vibration	13. The membrane across the inside of the ear. _____
N. Reflector	14. A part of the inner ear where sound vibrations are changed to nerve impulses. _____
O. Eardrum	15. Cominations of sounds that are pleasing and have small ratios. _____
P. Cochlea	
Q. Hammer	
R. Harmonious	

If the following statements are true, write the word true in the blank. If the statement is false, write the word false, and correct the underlined part of the statement so that it is now a true statement.

1. Large smooth surfaces will reflect sound to make an echo. _____
2. Sound travels in the form of vibrations. _____
3. Sounds travel faster in steel than in water. _____
4. Sounds travel in air with an approximate speed of 1100 feet per minute. _____
5. Sounds travel faster in water than in air. _____
6. A tight wire vibrates faster than a loose wire. _____
7. A long wire vibrates faster than a short wire. _____
8. A large wire vibrates slower than a small wire. _____
9. Sound boxes change the pitch of vibrating wires. _____
10. A piano has a wire for each different note. _____
11. A clarinet is a musical instrument that makes use of a vibrating diaphragm to produce sound. _____
12. An organ makes use of a vibrating column of air to produce sound. _____
13. Tuning forks with frequencies of 256 and 384 will produce a pleasing sound. _____
14. Vibrations leave the middle ear by way of the semi-circular canals. _____
15. The eustachian tube directs the sound into the eardrum. _____
16. You can hear everything that vibrates. _____
17. Sound travels faster through liquids than it will through air of solids. _____
18. Dogs are unable to hear sounds that have less than 180000 vibrations per second. _____
19. One cannot hear an alarm clock ringing in a vacuum jar because a clock will not ring without air. _____

20. You can hear the thunder before you see the lightning of most storms. _____
21. Two stones knocked together under water while your head is under water do not seem as loud as two stones knocked together in air. _____
22. If you see the lightning of a storm and did not hear the thunder for 20 seconds, the lightning would be 5 miles away. _____
23. Pitch depends on the amplitude of a sound wave. _____
24. Amplitude depends on how much air is set in motion. _____
25. An amplifier is a device that makes more air move. _____
26. Sound is always produced by air. _____
27. The sound produced by blowing across a bottle results from the air around the bottle moving. _____
28. The trumpet, trombone, and organ all produce sound by making a column of air vibrate. _____
29. The violin, piano, harp, and drum produce sound by making strings vibrate. _____
30. Lowering a vibrating tuning fork into water shows that water carries sound better than air. _____
31. Sound waves spread through the air parallel to the ground. _____
32. The pitch of a wire can be raised or lowered by tightening or loosening of the wires. _____
33. Wires may be set in vibration by tightening them. _____
34. Frequency depends on the material, its thickness, its tightness, and its length. _____

PRETEST 5, UNIT 8, MAGNETISM

Underline the best response to the following statements.

1. The iron ore which has magnetic properties is called____. (lodestone, cobalt, hematite)
2. Unlike poles____ each other, (attract, repel)
3. Like poles____each other (attract, repel)

4. A suspended bar magnet points____and____. (north and south, east and west)
5. The name of the material used to make temporary magnets is____. (soft iron, hard iron)
6. The name of the material used to make permanent magnets is____. (soft iron, hard iron)
7. The ends of a bar magnet are called____. (poles magnets)
8. In an unmagnetized bar of iron, the particles are arranged in an____ order, (orderly, irregular)
9. The earth acts like a magnet with____and____magnetic poles. (North and south, east and west)
10. The compass needle points toward the earth's____pole. (north,south)
11. A magnet will attract iron through____materials. (magnetic, non-magnetic)
12. A wire conducting an electric current acts like a____. (generator, magnet, filament)
13. The ends of a coil of wire conducting an electric current have ____and____poles. (north and south, east and west)
14. A wire conducting an electric current is surrounded with lines of _____. (force, resistance, gravity)
15. A coil of wire and an iron core, and a current flowing through the coil, make a____. (magnet, electromagnet, transformer)
16. A compass needle points along the earth's magnetic lines of____. (latitude, longitude, force)

TRUE OR FALSE:

17. The compass needle usually doesn't point true north or south.
18. One may increase the strength of an electromagnet by increasing the turns of wire.
19. One may increase the strength of an electromagnet by using a larger iron core.
20. One can make a permanent magnet with electricity.
21. A wire conducting an electric current deflects a compass needle.

22. A piece of soft iron placed across the ends of an electromagnet is called a keeper.
23. An apparatus to change the direction of a current in a motor or generator is called an alternator.
24. The imaginary lines around a magnet that represent the strength and direction of the magnetic force are called the lines of force.
25. A machine to change electrical energy into energy of motion is called an electric motor.
26. An iron core wound with wire carrying an electric current is called an electromagnet.
27. An object that attracts iron and certain other metals is called a magnet.
28. The force of attraction that a magnet has for iron, steel, and some other metals is magnetism.
29. Wood is a magnetic material.
30. A material not affected by a magnet is called a non-magnetic material.

FINAL TEST UNIT 8, MAGNETISM

- | | | |
|-------------------|--|-----|
| A. Armature | 1. The force of attraction that a magnet has for iron, steel, and nickel. | ___ |
| B. Computator | 2. To make into a magnet. | ___ |
| C. Compass | 3. A soft iron core wound with wire carrying an electric current. | ___ |
| D. Dot | | |
| E. Electric motor | 4. An ore containing iron that has magnetic properties. | ___ |
| F. Electromagnet | 5. The part of a generator that turns. | ___ |
| G. Iron | 6. The imaginary lines around a magnet that represent the direction and force of the magnetic field. | ___ |
| H. Lines of force | | |
| I. Magnetic field | 7. The area around a magnet which is affected by the magnet. | ___ |
| J. Magnetite | | |
| K. Poles | 8. The name of the ends of a magnet. | ___ |

- | | |
|--------------|--|
| L. Steel | 9. The material used to make temporary magnets. ___ |
| M. Magnetism | 10. A short interval between the clicks of a telegraph sounder. ___ |
| N. Magnetize | 11. The instrument that uses magnetism to tell direction. ___ |
| | 12. The apparatus to change the direction of current in an electric motor. ___ |

MULTIPLE CHOICE:

13. The action of like magnetic poles on each other is called (1) magnetism (2) attraction (3) repulsion. ___
14. The action of unlike magnetic poles on each other is called (1) magnetism (2) attraction (3) repulsion. ___
15. The parts of the earth toward which a compass points are called (1) north or south (2) the geographic poles (3) magnetic poles. ___
16. A wire conducting a current acts like a (1) compass (2) carrier (3) magnet. ___
17. The cores of an electromagnet are made of (1) electricity (2) soft iron (3) magnetism. ___
18. A compass needle points in the direction of the lines of force on the (1) atmosphere (2) earth (3) sun. ___
19. If a magnet is broken in half, the number of magnets formed (1) one (2) two (3) an infinite number. ___
20. A coil of wire carrying a current makes a (1) magnetic field (2) electromagnet (3) a permanent magnet. ___
21. The core of an electromagnet is made of (1) iron (2) steel (3) alnico. ___
22. The strength of an electromagnet is affected by (1) using a longer wire, (2) making more turns of wire, (3) using very hard steel. ___
23. A compass needle doesn't point true north and south because (1) of the electric wires in buildings (2) of the wobble in the earth's rotation (3) of the poor steel used in making compass needles (4) the magnetic poles of the earth are some distance from the earth's geographic poles. .

24. In an electric bell, when the circuit is closed and electricity is going through the wire, (1) the cores of the electromagnets are magnetized (2) the cores of the electromagnets are not magnetized (3) the bell will not ring until the circuit is opened. _____
25. In an unmagnetized iron bar, the particles are arranged in an (1) irregular order (2) regular order (3) order with all the north ends pointing north and all south ends pointing south. _____
26. A magnet will attract iron through (1) iron, glass, wood, or paper, (2) all nonmagnetic materials (3) only magnetic materials. _____
27. A wire conducting an electric current is surrounded with (1) iron filings (2) lines of force (3) heat waves and light waves. _____
28. You can make a permanent magnet with electricity by (1) placing an iron bar in a coil of wire carrying a current (2) placing a steel bar in a coil of wire carrying a current (3) placing an iron bar in a coil of wire and turning the electricity on and off several times. _____
29. A wire conducting an electric current causes the point of the compass needle to (1) turn at right angles to the wire (2) be repelled (3) spin around wildly. _____
30. The armature of a motor turns because of the (1) attraction and repulsion between the poles of the armature and the magnets (2) electricity (3) magnets. _____
- 31-32. Draw two diagrams showing how the molecules are arranged in (A) an unmagnetized bar of iron, (b) a magnetized bar of iron.
34. Make a drawing to show the path and direction of the lines of force of a bar magnet.
35. Make a drawing to show the magnetic field between two like magnetic poles.
36. Make a drawing and show the magnetic field between two unlike poles.

37. Make a drawing to show the path and direction of the lines of force for a horseshoe magnet.
38. When a magnet is cut into pieces, each piece is itself a magnet. Draw a diagram explaining this.
39. Draw a long bar magnet and show how the direction of the compass needle changes as you move it around the long magnet.
40. Make a drawing to show how to wind the wire around a U-shaped bar of iron so the ends of the bar will have opposite poles when a current flows through the wire.

PRETEST 6, UNIT 5, LIGHT

Underline the word that best completes the following statements.

1. Any material that will not let light pass through it is said to be___. (opaque, translucent, transparent)
2. A mirror in which the curvature is away from you is said to be___. (convex, concave, warped)
3. A lens which is thickest at the center is said to be___. (concave, convex, warped)
4. The bouncing back of light from an object it hits is known as___. (reflection, refraction, radiation)
5. An object which lets light pass through it but you cannot see through it is said to be___. (opaque, translucent, transparent)
6. The fine thread or wire in an electric incandescent lamp is called a___. (carbon, filament, frame)
7. Any object which lets light pass through it is said to be___. (opaque, translucent, transparent)
8. An object turned upside down is said to be___. (erect, inverted, opaque)
9. An object right side up is said to be___. (erect, inverted, opaque)

10. Bands of colored light made by passing light through a prism form a___. (spectrum, shadow, image)
11. A triangular-shaped piece of glass that separates a light into the colors is called___. (prism, a triangle, a lense)
12. The picture you see of yourself in a mirror is called the___. (spectrum, shadow, image)
13. The image you see of an object in a flat mirror is___. (reversed, inverted, transparent)
14. A lens which is thinnest at the center is said to be___. (convex, concave, warped)
15. The area behind an opaque which does not receive any light is called___. (spectrum, shadow, image)
16. The speed of light in miles per second is___. (186,000; 1,860; 186)
17. The point where rays of light are brought together by a lens is called its___. (shadow, focus, image)
18. The color that is bent most by a prism is___. (red, white, blue)
19. The color of light bent least by a prism is___. (red, white, blue)
20. The color of sunlight is___. (red, white, blue)

TRUE AND FALSE:

21. Fire was one of man's earliest sources of light.
22. Edison invented the incandescent lamp in 1779.
23. The filament used in incandescent lamps is tungsten.
24. Rough surfaces are good reflectors of light.
25. Dark-colored surfaces made good reflectors.
26. When light strikes a rough surface, it scatters in all directions.
27. You can see your image in rough surfaces.
28. The images of objects in mirrors are reversed.
29. Convex mirrors curve away from you.
30. Your image in a flat mirror is inverted.

31. Glass is a good reflector of light.
32. Light travels in straight lines.
33. Shadows are formed by placing an opaque object in front of a light source.
34. Light is bent when it passes from air into water.
35. A convex lens forms an inverted image.
36. A prism bends some colors more than others.
37. A black cloth is a poor absorber of light.
38. White is a good reflector of light.

FINAL TEST UNIT 5, LIGHT

1. The point where rays of light are brought together by a lens is called a (A) focal length (B) focus (C) an image. 1.____
2. Dark colored surfaces make good (A) reflectors (B) absorbers (C) inverters of light. 2.____
3. When light strikes a rough surface, it (A) is absorbed (B) scatters in all directions (C) reflects and forms an image. 3.____
4. The images of objects in mirrors are (A) erect (B) reversed (C) inverted. 4.____
5. Light is bent when it passes from air into (A) air (B) water (C) solids. 5.____
6. In burning fuels, light results from the incomplete combustion of the (A) light (B) heat (C) fuel. 6.____
7. Objects are visible only when (A) they are luminous (B) light reflecting from an object reaches your eye (C) they are non-luminous. 7.____
8. When light reflects from rough aluminum foil it is said to be reflected (A) regularly (B) irregularly (C) as a beam of visible light. 8.____
9. A beam of light becomes visible if there is smoke in the room because (A) smoke is luminous (B) smoke is white (C) the smoke particles reflect light. 9.____

10. The mirror that will produce an inverted image is the (A) flat mirror (B) concave mirror (C) convex mirror. 10.____
11. The mirror that will always produce a smaller image is the (A) flat (B) concave (C) convex mirror. 11.____
12. A convex lens will (A) reduce (B) enlarge (C) not change the size of an image. 12.____
13. In aiming a gun you make use of the fact that light travels (A) very fast (B) great distance (C) in a straight line. 13.____
14. A pencil appears bent when it enters the water because (A) water warps wood (B) water will not carry light waves (C) light travels at different speeds in different substances. 14.____
15. When you look at a blue sweater through a piece of red glass, the sweater appears to be (A) red (B) blue (C) green (D) black. 15.____
16. Draw a diagram showing how a prism will break up white light into a band of colors. Explain why this happens and what colors result.
17. Draw a diagram showing why a convex lens forms an inverted image.
18. Draw a diagram showing why an opaque object will cast shadows, one of which is darker than the other.
19. Draw a diagram showing why a concave mirror inverts the object that it reflects, and why a convex mirror makes the images it reflects seem smaller than actual size.

APPENDIX B
PART I
THE WRITTEN INSTRUCTIONS AND ACTIVITIES PERFORMED
BY THE INDIVIDUAL LABORATORY GROUP

UNIT 2, FIRE

Eight activities were completed, seven of these by the laboratory group. They are:

1. Temperature and Fire
2. The Kindling Temperature
3. Is Air Necessary For Fire?
4. How Does Oxygen Help Substances Burn?
5. What Are the Products of Combustion?
6. How Can You Make Charcoal?
7. What Are Fuels Made Of?
8. What Happens When You Burn Hydrogen?
(This was demonstrated for both groups.)

I. Temperature and Fire.

Materials Needed:

1. farmers matches
2. candle
3. block of wood
4. piece of coal
5. bunsen burner

A. Touch a lighted match briefly to the cold wick of a candle.

Then hold another lighted match under a large piece of wood.

Next hold a match under a piece of coal.

Did you start a fire in any of your trials?

Did you raise the temperature in each substance? How?

How much heat do you need to start a fire?

B. Now try these conditions.

- (1) Hold the lighted match near the wick of the candle for a longer time.
- (2) Try holding a piece of wood over the lighted bunsen burner.
- (3) Try holding a piece of coal over the lighted bunsen burner.

What happened in each of these trials?

What change was made in each of these cases?

In which case was more time used to raise the temperature?

In which case was more time used and a higher temperature used?

What can you conclude about the methods that can be used to make various materials burn?

II. The Kindling Temperature. Do different substances start burning at different temperatures?

A. Materials needed.

1. Cookie sheet
2. Coal
3. Waxed string
4. Paper
5. Matches
6. Bunsen burner

B. Directions.

1. Put the following on a metal plate: a piece of coal, some match-sticks, string, string dipped in lighter fluid, paraffin-coated string, and paper. Put these materials on

the metal plate provided, set the plate on the stand, and slide the lighted bunsen burner in under the metal plate. Watch the materials closely. Put down the order in which each one bursts into flame.

- a. What were the controls in this experiment?
- b. What conclusions can you make?

III. Is Air Necessary For Fires?

A. Material needed.

1. Glass plate
2. Candle
3. Matches
4. Chimney
5. Two pencils for sticks

B. Directions.

1. Stick a lighted candle to the glass plate provided on the table. Put a glass chimney over the candle. Let the chimney rest on some sticks (pencils) so it is not touching the plate. See what happens to the flame. Now remove the small sticks so the chimney is on the glass plate. Watch the flame. What happened in all three cases?
 - a. What was the variable?
 - b. Did it have any effect on the Fire?

IV. How Does Oxygen Help Substances Burn?

A. Materials needed.

1. Wood splint
2. Mercuric oxide
3. Bunsen burner
4. A test tube
5. A teaspoon of H_2O^2
6. A test tube holder

B. Directions.

1. Heat the H_2O_2 in the test tube.
2. Put a glowing wood splint in a bottle of ordinary air.
3. Take the same glowing splint and put it down into the test tube where O_2 is being formed.
 - a. What happens?
 - b. Does the oxygen make the splint burn faster?

V. What Part of the Air is Oxygen?

A. Materials needed.

1. Steel wool and water
2. A test tube, ring stand, and clamp

B. Directions.

1. Put a small amount of steel wool in a test tube.
2. Fill the test tube with water, shake it well, pour off the water.
3. Put the test tube, mouth down in a beaker of water.
4. Hold the test tube with a clamp fastened to the ring stand.
5. Measure the length of the tube above the level of the water in the tube.
6. Prepare a second test tube in the same way but do not put any steel wool in it.
7. Measure the length of this second tube above the level of the water in the tube.
8. Let the experiment stand 24 hours. Then measure again how high the water has risen in each tube. Compare these measurements with the first ones you took.

C. Questions and Observations.

1. What changes do you observe?
2. What was the purpose of using the second tube without the steel wool?

3. What changes do you observe in the steel wool?
4. a. Why did the water rise in the test tube?
b. How much did the water rise?
5. How much of the air is oxygen?

VI. How Can You Make Charcoal?

A. Materials needed.

1. A Bunsen Burner
2. A test tube, fitted with a one-hole stopper
3. A short glass tube
4. Wood splints

B. Directions.

1. Use a hard glass test tube fitted with a one-hole stopper with a short glass tube in it. Put some wood splints into the test tube. Heat the test tube containing the splints with a Bunsen burner.

C. Questions.

1. Will the gas given off at the end of the short glass tube burn?
2. What kind of material is left in the test tube?
3. After the tube has cooled, remove the remaining material. What is its form?
4. Is it soft, or brittle?
5. Can you write with it?

D. Directions.

1. Place pieces of it on a wire screen and heat them with the Bunsen burner again. What happens?
2. Pure charcoal glows as it burns, without forming much of a flame. Is the material you removed from the test tube and reheated charcoal?

VII. What is There in Fuels That Makes Them Burns?

A. Materials needed.

1. Small piece of cloth
2. Test tube, Bunsen burner

B. Directions

1. Place a small piece of cloth in the bottom of a test tube.
2. Slowly heat the test tube over a Bunsen burner. Be careful not to allow the cloth to burst into flames.

C. Questions.

1. What changes occurred in the cloth?

D. Directions.

1. Repeat the above experiment using the following: paper, wood, and sugar.

E. Questions.

1. What changes do you observe in each?
2. Hold this black substance in the flame. What happens?
3. What is the substance which remained in each case?
4. What is there in fuels that makes them burn?

UNIT WATER

Eight activities were completed. Five of these were done independently by the laboratory work group. They are:

1. How much water does a tomato contain?
2. Evaporation is a cooling process.
3. Water contains many impurities.
4. Looking at a drop of water.
5. How can solids be removed from water?

The following were demonstrated for both groups.

6. A demonstration of the water cycle.
7. The distillation of fresh water from salt water.
8. How water vapor forms clouds.

UNIT, WATER

I. How much water does a solid contain?

- A. Materials: tomato or potato, bread, copper sulfate, evaporating dish, forceps, bunsen burner, balance scale.
- B. Directions: Weigh a slice of tomato (or potato) and a small dish to put it in. Put the dish with the tomato in it over a low flame. Heat it very gently until the tomato is dried up from the heat of the flame. Now weigh the dish again. Record the following facts as you do the experiment.

1. Weight of the original slice of tomato. _____
2. Weight of dish and tomato before heating. _____
3. Weight of dish and tomato after heating. _____
4. Number (2) minus (3) _____

This should equal the weight of the water in the tomato.

Repeat the above experiment using a piece of bread provided.

1. Weight of the bread before heating. _____
2. Weight of dish and bread before heating. _____
3. Weight of dish and bread after heating. _____
4. Number (2) minus (3), = the water in bread. _____

Repeat the above procedure using copper sulfate.

1. Weight of the copper sulfate before heating. _____
2. Weight of the dish and copper sulfate before heating. _____
3. Weight of the dish and copper sulfate after heating. _____

4. Number (2) minus (3) = the water in the copper sulfate _____

C. Questions:

1. How much water did you find in the slice of tomato? _____
2. How much water did you find in the bread? _____
3. How much water did you find in the copper sulfate? _____

What can you conclude about water and living things or things that were alive at one time, and water and some solids? Use back.

UNIT, WATER

II. Evaporation is a cooling process. Water and alcohol evaporate at different rates.

A. Materials: water, alcohol, and watch glasses, a medicine dropper.

B. Directions: Water and alcohol evaporate at different rates.

1. Put some water on the back of your hand. Blow on your hand.

Results?

2. Put some alcohol on the back of your hand. Blow on your hand.

Results?

In which experiment did your hand feel the coldest? (1 or 2)

Evaporation causes cooling.

1. Place the two watch glasses provided on the table. Put three drops of water in one glass. Put three drops of alcohol in the other. Fan air across the two dishes. Which of the liquids evaporates first?
2. Using the hygrometer provided, wrap and tie the dry cloths provided around the bulbs of the two thermometers. Moisten one of the cloths with water and the other with alcohol. Swing the hygrometer around and take thermometer reading each minute for several minutes.

What results do you observe?

What liquid evaporated the fastest and caused the greatest temperature drop?

UNIT, WATER

III. WATER CONTAINS MANY IMPURITIES.

A. Materials: Two small beakers, soil, water, a stirring rod, washed sand, and a coffee can. Punch a hole in it.

B. Directions: Put equal amounts of soil in two small beakers.

Fill beakers with water and stir rapidly until the water becomes very muddy. Put one beaker aside where it will not be moved for a time. (24 hours)

In the tin can provided, fill the can with sand and pour the ether beaker of muddy water into the sand. Catch the water in a clean beaker as it comes out the bottom of the can.

C. Questions:

1. What change did you observe in the beaker of muddy water 24 hours later?
2. What change did you observe in the water that dripped out the hole in the bottom of the coffee can?
3. What caused the change?
4. In what two ways can solids be removed from water?

a.

b.

UNIT, WATER

IV. MICROSCOPIC IMPURITIES IN WATER.

A. Materials: a microscope, glass slide, pond water, a medicine dropper.

B. Directions: Take the medicine dropper and draw a few drops of water out of the beaker of pond water. Put a drop on of the glass slides provided and place it under the microscope for observation.

What do you observe?

Make a sketch or illustration of any plant or animal life that you observed.

UNIT, WATER

V. HOW CAN SOLIDS BE REMOVED FROM WATER BY USING A FILTER?

- A. Materials: Two small beakers, water, stirring rod, cotton, washed sand, washed gravel, charcoal.
- B. Directions: Put equal amounts of soil in two small beakers, fill them with water, stir rapidly. This should make the soil very muddy. If it does not, add a little more soil.

Take an empty coffee can or tall juice can, punch a hole in the bottom. Put a layer of cotton, washed gravel, washed sand, charcoal, and sand in the can. Pour one beaker of muddy water into the juice can and catch the water in a clean beaker as it drips out the hole in the bottom.

What change do you observe in the appearance of the water?

Using the microscope, compare a drop of muddy water from beaker number 2 to a drop of water dripping from the juice can.

UNIT WEATHER

Six experiments were completed in the study of this unit. Three were completed by the laboratory work group. They are:

1. What effects does heating have on air?
2. Why do direct rays of the sun produce more heat than slanted rays do?
3. How does a hygrometer measure the humidity of the air?

The following were demonstrated for both groups.

4. What happens to water vapor when it is cooled? (Text p. 99)
5. How does a thermometer work? (Text p. 111)
6. How does a barometer work? (Scott Foresman Text 8, p. 63)

UNIT, WEATHER

I. WHAT EFFECTS DOES HEATING HAVE ON AIR?

- A. Materials: A candle, matches, a lantern chimney, two sticks, and a punk.
- B. Directions: Light a candle and put a chimney over it. Prop the chimney up with two pencils. Take the lighted punk and do the following.
1. Hold the punk near the opening of the chimney at the bottom.
What happens?
 2. What can you observe about the weight of the warmed air?
 3. Do you think that wind outdoors is or could be produced the same way when the air, warmed by the sun that has heated land areas, begins to rise?
 4. Draw a diagram showing the direction of the air currents suggested by the smoke of the punk when the punk was held near the top of the chimney and when it was held near the bottom of the chimney.

II. WHY DO THE DIRECT RAYS OF THE SUN PRODUCE MORE HEAT THAN SLANTED RAYS DO?

- A. Materials needed: a flashlight, pencil, paper, two thermometers, sunlight, two pans of sand.
- B. Directions:
1. Wrap a roll of paper around a flashlight. Hold the flashlight directly above a piece of paper and direct the beam of light from the flashlight to the piece of paper. Draw a line around the area that is lighted when the beam strikes the paper.

Now hold the flashlight so the light hits the paper at an angle. Draw a line around the area that is lighted when the flashlight is turned on.

Which area was larger?

If this light had been sunlight, which area do you think would be heated more?

UNIT, WEATHER

2. Place the two pans of sand in the sunlight. Place one so that the rays of the sun strike it at right angles, and the other at angles of about 45 degrees. Place a thermometer in each pan. After several minutes, take the readings of the two thermometers.

What do you observe?

Do the direct or slanted rays of the sun heat the earth in the pans the most?

Do the direct or slanted rays of the sun heat the earth's surface the most?

III. HOW DOES A HYGROMETER WORK?

- A. Materials needed: a hygrometer attached to a handle, a small piece of cloth, water.
- B. Directions: Take the hygrometer and attach a small piece of cloth around the bulb of one of the thermometers of the hygrometer. Moisten the cloth. Swing the hygrometer around for several minutes, stopping occasionally to check the readings of the two thermometers. What change did you observe?

Which thermometer registered a drop in temperature? Why?

If the air had been very moist in the room today, what effect might this have on your observations?

Using the table, compute the approximate humidity in the air in the room today.

UNIT SOUND

Five experiments were completed in this unit of study. The laboratory work group completed all five. They are:

1. Sound waves must be carried by something.
2. How are sound waves controlled?
3. Why are some sounds pleasing?
4. How do musical instruments make sound?
5. How does the tightness and length of a wire affect the pitch?

I. SOUND WAVES MUST BE CARRIED BY SOMETHING.

- A. Materials needed: A bell jar and vacuum pump, an alarm clock, a felt pad.
- B. Directions: In groups of three or five, attach a vacuum pump to the bell jar air jet. Put the alarm clock on the felt pad inside the bell jar. Pump as much of the air out of the bell jar as you can. Wait for the alarm to ring. When the clapper strikes the bell you know it is ringing. Let the alarm ring.

Can you hear it? Why?

Repeat the experiment and while the alarm is ringing, gradually let some air back into the jar as the alarm is ringing. What happens?

Why are you unable to hear the ringing of an alarm clock clearly when the air is pumped out of the jar?

II. HOW ARE SOUND WAVES CONTROLLED?

- A. Materials needed: a megaphone, a ceiling tile, an alarm clock, a small box.
- B. Directions: While someone is talking through the megaphone, stand behind him, then beside him, and finally in front of him.

Describe the differences you hear in these three positions.

- 1.
- 2.
- 3.

Why do you think cheerleaders sometimes use a megaphone?

Explain how a megaphone directs sound waves in a particular direction.

Examine the samples of ceiling tiles provided. Place the alarm clock in the shoebox provided and while the alarm clock is ringing cover the box with one of the squares of ceiling tiles.

What happens?

How do ceiling tiles help reduce noise?

Why are the holes in the ceiling tile important?

III. WHY ARE SOME SOUNDS PLEASING?

- A. Materials needed: a bicycle, cardboard strips, clamps, tuning forks.
- B. Directions: Fasten a card to a bicycle wheel so that it hits the spokes of the rear wheel. Now turn the wheel slowly. What kind of sound do you hear? Turn the wheel faster. What kind of change do you observe in the sound as the wheel goes faster?

What conclusion can you make as to how to produce sounds of different pitch?

What must be changed to produce sounds of different pitch?

Set in vibration tuning forks which have frequencies of 256 and 512. Place the lower end of the forks on a table. Is the sound pleasing?

Try combinations of the other forks provided. What combinations are not pleasing?

Find the ratios of some of these combinations. What can you conclude about pleasing combinations? i.e., their ratios.

What did you observe about the ratios of the combinations of frequencies that are not pleasing?

After a tuning fork has seemingly stopped producing sound, hold the fork close to your ear. Has the pitch changed? Explain.

IV. HOW DOES THE TIGHTNESS OF A WIRE AFFECT THE PITCH?

- A. Materials needed: Two boards, wire, weights, two wires of different diameters.
- B. Directions: With the board provided, stretch the wire from the nail in the board across the two bridges and over the end of the board. Tie a small weight to the end of the wire. Gradually add more and more weights. Pluck the wires each time. What happens to the pitch? Why?

How does a violinist cause the strings to vibrate?

How does the violinist change the tightness of the strings when he tunes his instrument?

How does the length of a wire determine pitch?

Directions: Use the wires mounted on the board as in the first experiment, and leave the same weights on the wires, but move the bridges closer together. Pluck the wires between the bridges that have been placed under the wires. Listen to the sound. What do you observe?

Is a higher or lower pitched sound produced when the bridges are moved closer together?

How does the violin player shorten the strings on his violin?

Mount the two wires of different diameters on the second board. Put the same weights on each wire to assure that the length and tightness of the strings are the same. Pluck one of the wires, then the other. What do you observe? Is the pitch the same?

Which wire produces the higher-pitched sound?

What can you conclude about the thickness of a wire in determining the pitch?

In what three ways have you found that you can produce a higher pitch?

- 1.
- 2.
- 3.

V. HOW DO MUSICAL INSTRUMENTS MAKE SOUND?

A. Materials needed: two test tubes, a piece of one inch tubing (glass) two feet long, fitted with a plunger, a piece of copper tubing with a hole drilled in it.

B. Directions:

- (1) Take two test tubes that are the same size. Fill one of them half full of water. Blow across each one. Which one has the higher pitch?

Do shorter columns produce sounds of higher or lower pitch?

What musical instrument has a slide which can continually be moved to adjust or change the length of the air column?

- (2) Take the piece of one inch glass tubing fitted with a plunger and blow across the opening. Move the plunger up and down.

How does the pitch change when you change the length of the air column?

- (3) Take the piece of copper tubing supplied, blow across the open end. At the same time put your finger over the hole that was drilled in the tubing. Remove your finger and blow again. What is the result?

Here you shortened the length of the vibrating air column when you removed your finger from the hole.

What musical instrument operates in this manner, but uses valves to control the length of the air column?

UNIT MAGNETISM

All of the following experiments were performed by the laboratory work group. Eight experiments were completed in this unit of study. They are:

1. Finding the poles of a magnet
2. How to make a magnet
3. What materials are attracted by a magnet
4. Making a compass
5. How do the lines of force affect a compass?
6. Will a magnet attract pieces of iron through non-magnetic materials?
7. How is electricity used to make magnets?
8. How to make an electromagnet.

UNIT, MAGNETISM

I. FINDING THE POLES OF A MAGNET

A. Materials needed: Two bar magnets, a wire cradle, thread or string, a piece of chalk.

B. Directions:

- (1) Suspend a bar magnet in the cradle from a string. Mark the end of the suspended magnet pointing north continually. Now bring one end of the other bar magnet near the marked pole of the suspended magnet. What do you observe?
- (2) Reverse the magnet in your hand and bring the other pole near the marked pole of the suspended magnet. What do you observe?

Do they react in the same way?

What can you conclude about the attraction of like and unlike poles of magnets?

- (3) Make a sketch showing the attraction or repelling action of like and opposite poles of a magnet.

II. HOW TO MAKE A MAGNET

- A. Materials needed: Two steel knitting needles or big nails, a bar magnet, compass, iron filings.
- B. Directions: Using the knitting needles provided, stroke the needle, or nail, several times with the bar magnet provided. After stroking the needle several times, test your results by using the needle to pick up iron filings.

Results?

Approach a compass with your magnetized needle. What happens?

Reverse the needle in your hand and approach the compass again. Results?

III. WHAT MATERIALS ARE ATTRACTED BY A MAGNET

- A. Materials needed: A bar magnet, pencil, soap, glass, paper, a nail, a penny, an American nickel, a needle, a dime, pins, rubber, charcoal, a rock, a door knob, mercury, wax, aluminum foil, a gold object (watch band), a tin can, lead, bread.
- B. Directions: Using the bar magnets, test the following materials to find out whether they are attracted by a magnet or not. See the materials listed above.

From your observations, what materials were attracted by the magnet?

What materials do all these objects have in common?

What can you conclude about all materials attracted by a magnet?

IV. MAKING A COMPASS

- A. Materials needed: A bar magnet, thread, a needle, piece of cork, water, a tumbler.
- B. Directions: Hang a bar magnet from a piece of thread. When the bar has stopped turning, observe what direction the bar points.

Magnetize a needle by rubbing it with a bar magnet. Place the needle carefully on a large piece of cork and put the cork with the needle on it in the water. Wait until the water and cork are perfectly still. Check the direction of the needle. What do you observe?

What can you conclude about the needle in a commercial compass?

V. HOW DO THE LINES OF FORCE AFFECT A COMPASS?

A. Materials needed: A bar magnet, compass

B. Directions:

1. Place the bar magnets provided end to end in such a way that the opposite poles are touching to make one long magnet. Slowly move the compass provided around the magnet in a circular path.
2. How does the direction of the compass needle change as you move it around the magnet's north pole? Its south pole?
3. How does the pointing of the compass needle compare with the lines of force around a magnet? The needle of a compass in a magnetic field points in the same direction as the lines of force.

In the space below, make a drawing of the way in which the compass needle points as one moves it around a bar magnet.

VI. A MAGNET WILL ATTRACT PIECES OF IRON THROUGH NON-MAGNETIC MATERIALS

A. Materials needed: A bar magnet, cardboard, a copper sheet, a plastic ruler, aluminum foil, wood, glass, a lead plate, a glass with water in it, a tin can lid.

B. Directions:

1. Place a piece of cardboard over the poles of a magnet and try to pick up a few paper clips.

What happened?

2. Repeat the experiment and put a copper sheet over the poles of the magnet and try to attract a few paper clips with the magnet.

Results?

3. Repeat the experiment using a plastic ruler, aluminum foil, wood, glass, a lead plate, a glass with water in it, and a tin can lid. See if the magnetic attraction of the magnet will pass through these materials and attract a few paper clips.

What can you conclude about the ability of the magnet to pick up magnetic materials through all of these shields?

4. What can you conclude about the force that magnets exert through magnetic and nonmagnetic materials?

VII. HOW IS ELECTRICITY USED TO MAKE MAGNETS?

A. Materials needed: copper wire, dry cell, iron filings, compass

B. Directions:

1. Connect a bare copper wire to the terminals of a dry cell battery. While the current is flowing through the wire, touch the other end of the wire to some iron filings.

Results?

Disconnect one wire from the dry cell. What happens?

2. What can you conclude about a wire carrying an electric current?
3. Repeat the experiment and test the wire for magnetism with a compass.

What do you observe?

VIII. THE ELECTROMAGNET

A. Materials needed: copper wire, a large nail, a $1\frac{1}{2}$ volt dry cell, paper clips.

B. Directions:

1. Using the wire and large iron nails provided, coil about twenty turns of the copper wire around a large nail. Connect the ends of the copper wire to the dry cell battery to make a complete circuit. Touch one end of the nail to some of the paper clips.

Results?

Now take one end of the copper wire off the connection of the dry cell battery. What happens?

2. Repeat the experiment. Coil about forty turns of wire around the nail. How many clips can be picked up now? How does increasing the number of turns of wire in the cell affect the strength of the electromagnet?

3. Repeat the above activities but use two $1\frac{1}{2}$ volt dry cells instead of one.

How many paper clips can be picked up now as compared to before?

4. In what two ways can the strength of an electromagnet be increased?

a.

b.

UNIT LIGHT

Nine experiments were completed in this unit. Six were completed by the laboratory work group. They are:

1. The reflection of light
2. Lenses
3. Mirrors*
4. Light travels in a straight path
5. The reflection of light
6. The composition of white light

The following experiments were demonstrated to both groups.

7. Why does a burning fuel give light? (p. 125)
8. How is light made with electricity? (p. 126)
9. What happens when colors are mixed? (p. 148)

*Experiment three was used to test the problem solving resourcefulness of both groups.

UNIT, LIGHT

I. THE REFLECTION OF LIGHT - Regular Reflection

- A. Materials needed: a flashlight, a small mirror, a rectangular box about twice the size of a shoe box, a punk, a pane of glass that can be substituted for a side of the box.
- B. Directions: Cut off one side of the box and tape the pane of glass in this place. (This may be already prepared for you). Light the punk and fill the smoke box with smoke. Shine the flashlight beam into the box filled with smoke. Is the ray of light clearly defined?
 1. Put a small mirror into the box, add some more smoke, and shine the flashlight beam on the mirror. Are the rays of light still clearly defined after reflection from the mirror?

2. Draw a diagram showing how the beams of light appeared to pass through the smoke and how they were reflected without scattering.
- C. Take a piece of clear cellophane and roughen it by rubbing it with a piece of steel wool until the surface has a uniformly dull appearance. Insert this into the box in place of the plane mirror that was in the beam of light.
 1. How does the ray of light that is reflected differ from before?
 2. Place your eye in direct line with the reflected beam from the mirror. Result?
 3. Repeat, using the dulled cellophane reflector. Describe and tell why there is a difference.

UNIT, LIGHT

II. WHAT HAPPENS TO LIGHT WHEN IT PASSES THROUGH LENSES?

- A. Materials needed: a convex lens, a concave lens.
- B. Directions: Use the convex lens and lay it on a printed page in your desk. Slowly draw the lens away from the printed page.
 1. What do you observe? Does the printing of the page become larger or smaller?
 2. Hold the convex lens at arms length and look at some distant object. What do you observe about the image seen through the lens?
 3. In the space below, draw a diagram showing how the beams of light are bent as they pass through the convex lens and produce the above observed results.
- C. Use the concave lens and lay it on some printing in your book and slowly draw the lens away.
 1. What do you observe?
 2. Hold the concave lens at arms length and look at some object in the distance. What do you observe about the image seen through the lens?

3. In the space below, draw a diagram showing how the means of light are bent as they pass through a concave lens to produce the observed results.

UNIT, LIGHT

III. MIRRORS

- A. Materials needed: concave and convex mirrors.
- B. Directions: Using the concave mirror, do the following exercises.
 1. Look into a concave mirror, what do you observe about the image that is formed?
 2. Take your pencil, lay it on the mirror and slowly move it away. When the pencil is about one-half inch away, what do you observe concerning the reflected image?
 3. As you move your pencil farther away from the mirror, what do you observe about the reflected image?
 4. In the space below, draw a diagram showing how the beams of light are reflected to cause each of the above results.
- C. Using the convex mirror, do the following exercises.
 1. Look into a convex mirror. What do you observe about the image that is formed?
 2. Take your pencil, lay it on the mirror and slowly draw it away. What do you observe concerning the reflected image when the pencil is about one, two, and three inches away?
 3. In the space below, draw a diagram showing how the beams of light are reflected to cause each of the above results.

UNIT, LIGHT

IV. LIGHT TRAVELS IN A STRAIGHT PATH

- A. Materials needed: four pieces of cardboard, a candle, a juice can, tissue paper.
- B. Directions:
 1. Using the four pieces of cardboard provided, (that already have a hole punched in them) arrange the cards so that when they are set up and arranged in a straight line you can look

through the holes in all four of them. Place a candle flame so that it can be seen by looking through all the cards when they are spaced about thirty centimeters (twelve inches) apart.

Now pull one of the cards a little out of line with the others and try to look through at the candle flame.

Can you see the flame? Why?

What does this show about light?

2. Using the pinhole camera provided (juice can with a hole in one end and tissue paper covering the other) observe a candle flame through the pinhole camera in the darkened area of the room.

What do you observe about the image received on the tissue paper?

How does this show that light travels in a straight line?

Draw a diagram showing how the image received becomes inverted.

UNIT, LIGHT

V. THE LAWS OF REFLECTION

- A. Materials needed: two pieces of cardboard with slits cut in them, a mirror, a stick that will stand by itself ahead of the mirror, large sheets of drawing paper. (18 x 24)

- B. Directions: Oral instructions given by your teacher will and must precede the following. FOR THESE, see p. 175 UNSECO SOURCE BOOK.

1. Bend the pieces of cardboard in the form of a stool. The ends form legs and in these legs cut a slit. Through this slit, sight the image of the stick that is reflected in the mirror. Then with your pencil, track down the path of light from the reflection of the stick in the mirror to the slits in legs of your cardboard stool. Repeat the activity sighting the reflection of the image in the mirror from the other side of the mirror.

Make a diagram of the position of your stool, the mirror, and the pencil marks that you made showing the path of the light reflected from the image of the stick reflected by the mirror.

What does this show you about the way in which light is reflected when it strikes a mirror?

2. Draw a broken line on a piece of paper with a ruler. Next draw a straight line from it at any angle. Set a mirror upright at the point where the two lines meet. Turn the mirror until the reflection of the dotted line is in line with the real dotted line. Now look into the mirror and line up one edge of your ruler with the reflection of the straight line. Draw this line with your pencil and measure the angles on each side of the broken line with a protractor.

Draw a diagram showing your work.

Repeat this activity and change the size of the angle.

Results?

What does this show you about the way in which light is reflected from a mirror?

UNIT, LIGHT

VI. THE COMPOSITION OF WHITE LIGHT

- A. Materials needed: a prism, sunlight, a piece of white cardboard.
- B. Directions: Adjust the window shade so that the sun comes through a narrow slit. Put a prism in this beam of light. Now turn the prism in this beam of light until you get a group of colors on the piece of cardboard.

Describe these colors.

Make a diagram and illustrate how a prism will break up a beam of white light into a band of colors.

What is this band of colors called?

Repeat the instructions above using a glass of water instead of a prism. Place the glass very full of water on the window ledge in the sunlight. Let it project a little over the inside edge of the window ledge. Place a piece of white paper on the floor. What do you observe?

What does a prism or water do to white light (sunlight)?

APPENDIX B

PART II

SURVEY OF STUDENT ATTITUDES QUESTIONNAIRE

AND

PROBLEM SOLVING ABILITIES EXPERIMENT

SURVEY OF STUDENT ATTITUDES QUESTIONNAIRE

The following questions were answered by the pupils who participated in the two laboratory groups in an attempt to survey the student attitudes and preferences concerning the two methods of laboratory instruction.

1. Do you enjoy doing laboratory work more than watching the experiment being performed by the teacher? 1. _____
2. Do you understand the experiment better when the teacher does it than when you do it yourself? 2. _____
3. Do you prefer to have the teacher do all the experiments or demonstrations? 3. _____
4. Do you prefer to have all individual laboratory work? 4. _____
5. Do you think that you could learn as much from a similar course having no accompanying laboratory work? 5. _____
6. Do you think that having individual laboratory work encourages you to work harder? 6. _____
7. Do you think that having individual laboratory work helped increase your interest in science? 7. _____
8. Do you think that individual laboratory work helped you to remember the facts? 8. _____
9. Do you think that waiting to do the experiment is too tiring? 9. _____
10. Do you prefer written to oral instructions? 10. _____

THE EXPERIMENT USED TO MEASURE
PROBLEM SOLVING ABILITIES

III. MIRRORS

A. Materials needed: concave and convex mirrors.

B. Directions: Using a concave mirror, do the following exercises.

1. Look into a concave mirror, what do you observe about the image that is formed?
2. Take your pencil, lay it on the mirror and slowly move it away. When the pencil is about one-half inch away, what do you observe concerning the reflected image?
3. As you move your pencil farther away from the mirror, what do you observe about the reflected image?
4. In the space below, draw a diagram showing how the beams of light are reflected to cause each of the above results.

C. Using the convex mirror, do the following exercises.

1. Look into a convex mirror. What do you observe about the image that is formed?
2. Take your pencil, lay it on the mirror and slowly draw it away. What do you observe concerning the reflected image when the pencil is about one, two, and three inches away?
3. In the space below, draw a diagram showing how the beams of light are reflected to cause each of the above results.

APPENDIX C
TEST RESULTS DATA

CLASS ROLE AND TEST SCORES OF VARIOUS UNITS
SCIENCE CLASS S-1

Name	I.Q.	UNIT I		UNIT II		UNIT III		UNIT IV		UNIT V		UNIT VI	
1. BONE, G.	87	7	26	17	34	19	28	15	37	15	32	18	19
2. EHNOT, G.	104	6	45	16	28	21	29	17	31	16	29	21	17
3. EVANS, A.	122	11	46	20	41	24	41	17	40	17	38	19	23
4. FOPP, C.	102	3	35	19	28	20	37	10	33	15	29	14	16
5. FORSMAN, D.	82	6	20	17	18	11	23	11	19	11	24	16	12
6. GADBAW, B.	116	2	41	14	32	21	30	13	36	7	25	13	17
7. GREGG, J.	111	9	42	19	36	16	35	16	39	10	27	18	13
8. LANDSVERK, K.	118	3	45	21	34	19	44	23	42	17	32	27	23
9. LESTER, B.	118	7	47	20	40	19	46	16	47	17	35	15	21
10. PROBST, E.	112	5	21	14	33	7	20	11	34	13	28	10	12
11. SABO, J.	114	4	47	16	38	27	45	16	44	14	36	17	17
12. SAMPSEL, C.	123	9	45	17	40	18	44	21	44	10	33	27	24
13. SAUNDERS, S.	93	1	21	19	20	10	15	10	29	10	21	12	13
14. SCOTT, J.	100	4	35	14	28	15	23	15	32	14	29	18	13
15. SHORT, R.	91	3	18	16	28	22	25	14	38	15	29	11	19
16. SOWA, A.	113	5	37	14	32	23	41	16	38	14	33	21	18
17. STEEN, D.	90	2	20	13	25	16	23	9	37	11	23	12	16
18. STOKES, R.	114	7	18	17	33	24	26	15	40	7	22	19	18
19. TANBERG, L.	104	10	42	20	32	16		16	48	16	37	19	16
20. VAMCIL, D.	120	15	45	11	33	25	42	23	48	16	38	31	25
21. WALTARI, G.	101	2	35	15	23	15	28	12	40	15	34	3	21
22. WHITE, J.	97	7	35	20	26	12	25	11	35	15	36	12	17
23. WILKINS, T.	98	6	41	15	28	24	35	18	37	15	38	24	17
24. BODTKE, V.	Incomplete data												
25. GRAVES, L	"	"											
26. LOCKE, S.	"	"											

CLASS ROLE
SCIENCE CLASS S-2

NAME	I.Q.	UNIT I		UNIT II		UNIT III		UNIT IV		UNIT V		UNIT VI	
1. DUNCAN, J.	104	7	43	17	39	17	39	18	35	7	27	23	21
2. DUNCAN, S.	102	9	37	17	36	12	37	13	34	9	28	12	17
3. LATTIN, R.	85	6	20	13	32	21	34	15	34	11	31	13	16
4. MANS, R.	112	10	48	21	40	28	46	24	46	16	37	15	25
5. MC BEE, E.	85	6	30	15	20	7	23	14	34	11	24	11	10
6. MC KAY, J.	101	2	27	12	21	11	20	10	32	Incomplete data			
7. MC LAUGHLIN, R.	106	8	33	18	43	17	34	15	34	10	32	16	13
8. MC NICOL, C.	126	7	46	17	37	17	37	18	44	11	30	24	16
9. MC GUIRE, G.	118	14	47	22	48	12	44	19	44	12	37	23	23
10. MORRIS, D.	117	15	46	22	43	22	45	21	44	11	36	21	21
11. NASH, L.	124	9	46	16	33	13	33	14	40	15	33	20	19
12. NIVENS, P.	116	3	31	14	31	13	34	15	40	11	29	17	15
13. PACHEK, M.	108	2	38	18	37	17	37	18	36	10	29	15	21
14. PAINTER, V.	114	8	45	15	40	14	33	15	41	9	27	17	19
15. PANDIS, D.	119	8	46	20	39	12	40	19	46	16	36	19	22
16. PISONE, S.	99	3	31	14	21	12	17	15	38	11	19	24	13
17. PRICHARD, R.	103	8	45	20	32	7	31	18	37	14	31	16	16
18. RANDALL, L.	113	7	45	18	34	14	30	16	37	12	27	19	23
19. ROGERS, E.	105	8	32	19	42	17	37	19	45	12	35	18	21
20. RUFF, P.	99	8	27	20	33	13	28	15	38	15	32	13	17
21. SANDERS, R.	106	6	31	15	30	21	36	18	36	15	30	20	16
22. SEIDLER, G.	111	6	39	16	34	11	30	17	37	14	32	21	14
23. ROBINSON, C.	108	14	40	22	28	24	35	14	34	15	21	13	17
24. WARGO, J.	113	5	40	21	38	14	31	16	43	13	30	19	17
25. SOTER, N.	120	3	46	17	43	12	34	18	49	12	38	26	23

CLASS ROLE
SCIENCE CLASS S-3

NAME	I.Q.	UNIT I		UNIT II		UNIT III		UNIT IV		UNIT V		UNIT VI	
1. ARGALL, W.	95	1	25	15	35	20	30	14	30	11	30	15	18
2. BALLEEN, M.	113	0	36	18	38	21	46	19	45	16	36	18	20
3. BLEND, J.	117	2	24	15	24	20	31	13	34	13	32	15	17
4. BUNKER, K.	113	4	42	12	40	16	32	16	40	12	35	9	21
5. BYERS, C.	112	5	45	21	42	26	45	25	43	16	38	28	20
6. CARLSON, C.	103	1	25	16	30	19	33	13	35	13	33	15	17
7. CLARK, R.	112	1	35	14	35	21	34	17	42	12	33	23	20
8. COONS, S.	123	7	45	20	35	24	37	17	39	15	37	18	19
9. ELLINGSTON, C.	106	3	37	16	35	19	37	15	42	15	36	14	20
10. ENGLE, L.	117	4	42	14	30	21	34	16	44	10	34	18	19
11. ENSLEY, L.	125	10	41	18	40	29	39	17	43	9	28	15	16
12. FIEBRANZ, C.	98	0	35	18	21	25	38	14	38	11	29	18	19
13. GODAK, G.	89	2	17	10	34	14	15	11	17	7	29	10	10
14. GRISMER, L.	84	1	40	19	35	19	26	18	35	7	20	20	15
15. HESS, J.	108	7	47	20	37	23	44	20	44	15	28	19	23
16. HUTTON, S.	111	4	43	13	39	26	45	21	46	11	28	21	21
17. JONES, R.	111	5	28	16	38	18	44	20	38	15	37	22	18
18. KNIGHT, S.	120	6	46	15	36	31	41	23	47	15	36	18	24
19. LUCINA, K.	107	2	42	16	37	29	39	18	39	15	31	19	16
20. MYRE, R.	91	4	43	13	34	16	34	13	37	13	30	16	17
21. NELSON, S.	95	7	25	17	35	16	33	12	44	14	32	20	16
22. ROSS, W.	103	10	34	23	35	28	37	19	43	16	37	16	20
23. STRAUSE, M.	122	2	45	19	43	26	43	23	45	17	36	20	25
24. WANIATA, D.	108	9	39	16	34	21	40	20	46	16	35	17	19
25. ZACEK, D.	115	9	44	20	37	19	40	19	44	15	32	18	19
26. WILLITS, I.	104	7	27	15	28	22	25	17	42	14	30	19	20

CLASS ROLE

SCIENCE CLASS S-4

NAME	I.Q.	UNIT I		UNIT II		UNIT III		UNIT IV		UNIT V		UNIT VI	
1. CUNNINGHAM	103	11	40	13	37	16	33	15	48	11	39	17	13
2. DAMON, H.	67	0	15	6	12	23	7	11	14	5	22	15	13
3. DENGEL, L.	112	incomplete data				20	33	18	43	-	-	-	-
4. DODGE, E.	81	2	11	13	12	17	5	5	25	7	24	15	6
5. HAGEN, G.	105	4	30	15	33	13	26	13	41	14	32	24	15
6. HAY, M.	102	4	24	15	25	17	20	13	30	15	27	15	13
7. HOPPER, M.	108	8	46	17	41	24	47	25	35	11	24	29	22
8. HOLT, D.	102	6	27	15	37	14	26	15	45	13	39	21	13
9. HRUBY, M.	-	incomplete data				-	-	-	-	-	-	-	-
10. HUMBLE, G.	103	incomplete data				-	-	-	-	-	-	-	-
11. HUGHES, J.	88	5	37	12	33	17	40	17	41	13	27	19	15
12. ISAKSON, D.	118	2	41	13	31	11	25	18	36	15	34	16	15
13. JAMES, J.	101	3	37	17	38	17	39	23	41	14	31	21	13
14. JOHNSON, A.	108	3	28	18	32	18	38	23	35	16	37	21	22
15. JOHNSON, G.	105	6	25	15	38	20	32	15	30	16	35	19	17
16. JOSEPHSON, B.	105	7	26	23	43	27	36	17	35	13	33	21	15
17. KEROWAC, B.	88	0	27	12	23	10	20	15	38	9	27	13	14
18. KJELSRUD, M.	113	4	44	23	42	14	44	25	48	17	38	31	23
19. KLEPZIG, K.	109	4	25	12	38	24	37	15	37	12	35	19	17
20. KNAPP, M.	102	1	21	15	25	14	30	12	33	14	30	17	13
21. LAMERE, J.	85	0	13	13	26	14	17	11	22	15	30	9	9
22. MC MASTER, L.	98	4	25	7	37	15	19	15	28	14	24	17	13
23. SWARTZ, G.	99	4	31	16	36	16	25	16	37	15	33	19	15
24. WHITLEY, D.	113	incomplete data				18	40	18	43	15	36	19	22

CLASS ROLE

SCIENCE CLASS S-5

NAME	I.Q.	UNIT I		UNIT II		UNIT III		UNIT IV		UNIT V		UNIT VI	
1. KNOTE, C.	112	0	37	13	27	12	31	16	39	13	27	18	17
2. LANG, D.	108	2	35	12	38	14	37	17	42	11	36	18	20
3. LAUGH, P.	118	3	46	18	39	17	43	21	40	13	34	25	23
4. LEITGEB, R.	97	2	37	16	40	17	38	18	41	11	35	16	21
5. LEVEQUE, K.	120	9	46	17	39	14	37	21	45	14	36	23	21
6. LEVEQUE, L.	93	1	20	14	32	13	15	14	38	11	39	19	11
7. LEWIS, A.	106	2	30	14	35	14	28	15	27	11	20	17	19
8. LUEDTKE, W.	92	2	20	19	32	7	28	9	36	15	28	10	20
9. LURASS, M.	91	4	35	15	25	9	27	11	38	15	35	12	14
10. MADSON, J.	102	1	38	17	34	25	24	15	32	10	19	17	14
11. MALISANI, L.	102	3	32	13	43	13	40	23	41	11	23	30	17
12. MANN, D.	127	10	47	18	43	22	45	21	46	18	43	18	21
13. MARBLE, R.	120	8	48	16	41	16	43	19	44	13	37	20	23
14. MARIANETTE, L.	108	2	32	13	29	18	31	19	40	13	36	20	12
15. MATHIAS, C.	110	3	36	15	32	16	37	13	41	12	35	15	18
16. MC BEE, K.	71	0	20	5	22	13	7	11	27	6	15	9	8
17. MC CANN, L.	105	2	38	14	26	17	43	18	40	12	28	20	17
18. MC PHERSON, M.	118	4	47	11	42	18	47	21	44	17	38	22	25
19. MEHIHOFF, S.	111	3	47	16	30	12	37	17	40	15	32	18	9
20. MURPHY, C.	113	6	31	16	29	14	34	15	36	11	33	13	15
21. MUZZANA, R.	117	2	46	18	41	19	39	25	47	17	39	23	19
22. OPIE, J.	104	2	39	13	36	17	39	19	44	18	38	20	22
23. WEISSMAN, P.	120	8	46	17	40	10	41	18	44	15	37	19	21
24. WHITMORE, P.	95	incomplete data				-	-	-	-	-	-	-	-
25. MC BRIDE, B.	-	2	20	-	28	22	-	-	-	17	-	-	-
26. KNUDSON, D.	-	-	-	-	-	17	37	19	36	15	33	13	14

CLASS ROLE

SCIENCE CLASS S-9

NAME	I.Q.	UNIT I		UNIT II		UNIT III		UNIT IV		UNIT V		UNIT VI	
1. EASTMAN, G		3	30	17	27	17	26	15	40	15	36	15	15
2. FAYLER, L.		5	45	21	39	14	38	23	45	17	38	19	22
3. FLEGEL, R.		8	35	18	35	17	38	15	41	11	37	22	18
4. GOULET, C.		3	20	21	10	14	27	9	27	11	35	9	9
5. GANGNER, D.		2	35	11	22	14	29	13	35	12	25	13	15
6. MISCHELOTTE, G.		8	30	19	25	13	25	17	36	15	25	22	17
7. SULLIVAN, V.		7	46	17	34	17	38	15	45	17	37	18	15
8. TAYLOR, P.		4	37	18	37	13	34	14	39	15	36	13	14
9. TRAMILLI, M.		4	45	16	25	16	34	16	35	15	32	18	17
10. TRIPP, J.		3	30	15	20	13	37	19	36	15	33	21	15
11. VICK, J.		5	46	17	31	17	39	18	44	17	38	17	16
12. WAHL, J.		5	31	13	28	10	24	15	34	15	33	16	7
13. WALKER, M.		3	32	17	29	19	31	18	35	16	28	18	12
14. WALKER, S.		5	45	21	38	15	40	15	43	21	38	18	13
15. WAYMIRE, P.		8	30	19	30	14	28	12	32	12	31	15	15
16. WEAR, N.		11	45	24	43	18	44	21	44	17	37	25	13
17. WESCHE, S.		6	34	15	38	13	40	19	36	19	37	22	16
18. WEST, S.		3	47	17	42	19	47	23	47	17	31	17	19
19. WESTON, K.		6	30	16	30	17	22	12	25	14	32	20	16
20. WETZEL, B.		0	20	14	12	5	17	5	36	11	25	16	2
21. WHITEHOUSE, R.		7	17	11	20	10	22	6	27	12	31	17	7
22. WILDA, J.		13	45	17	47	18	39	22	47	19	37	24	19
23. WILLEY, M.		2	36	18	26	16	40	9	39	15	38	16	11

CLASS ROLE

SCIENCE CLASS S-9

NAME	I.Q.	UNIT I		UNIT II		UNIT III		UNIT IV		UNIT V		UNIT VI	
24. WOLFE, J.		4	30	18	23	13	22	11	34	15	25	16	13
25. WOOD, S.		1	45	16	23	12	35	13	38	15	30	18	19
26. YOUNG, G.		1	20	14	16	13	6	7	18	11	26	15	12
27. ZAHARA, P.		5	42	18	37	18	35	20	41	15	34	22	16
28. ZORNER, R.		8	45	14	42	17	36	21	45	16	36	16	18

APPENDIX D
DATA OF STUDENTS MATCHED BY I.Q.
AND
PRETEST SCORES

ORIGINAL DATA
MATCHING STUDENTS BY I. Q.

CONTROL GROUP								EXPERIMENTAL GROUP																				
		FIRE		WATER		WEATHER		SOUND		LIGHT		MAGNETISM				FIRE		WATER		WEATHER		SOUND		LIGHT		MAGNETISM		
NAME	I.Q.	P	F	P	F	P	F	P	F	P	F	P	F	NAME	P	F	P	F	P	F	P	F	P	F	P	F	P	F
	104	6	45	16	28	21	29	17	31	21	17	16	29		7	17	15	28	22	25	27	42	19	20	14	30		
	122	11	46	20	41	24	41	17	40	19	23	17	38		10	41	18	40	29	39	17	43	15	16	9	28		
	116	2	41	14	32	21	30	13	36	13	17	7	25		9	44	20	37	19	40	19	44	18	19	15	32		
	111	9	42	19	36	16	35	16	39	18	13	10	27		4	43	13	39	26	45	21	46	21	21	11	28		
	118	3	45	21	34	19	44	23	42	27	23	17	32		14	47	22	48	12	44	19	44	23	23	12	37		
	118	7	47	20	40	19	46	16	47	15	21	17	35		6	46	15	36	31	41	23	47	18	24	15	36		
	112	5	21	14	23	7	20	11	34	10	12	13	28		1	35	14	35	21	34	17	42	23	20	12	33		
	114	4	47	16	38	27	45	16	44	17	17	14	36		8	45	15	40	14	33	15	41	17	19	9	27		
	123	9	45	17	40	18	44	21	44	27	24	10	33		7	45	20	35	24	37	17	39	18	17	15	37		
10.	93	1	21	19	20	10	15	10	29	12	13	10	21		1	20	14	32	13	15	14	38	19	11	11	39		
	100	4	35	14	28	15	23	15	32	18	13	14	29		6	31	15	30	21	36	18	36	20	16	15	30		
	91	3	18	16	28	22	25	14	38	11	19	15	29		4	43	13	34	16	34	13	37	16	17	13	30		
	113	5	37	14	32	23	41	16	38	21	18	14	33		7	45	18	34	14	30	16	37	19	23	12	27		
	114	7	18	17	33	24	26	15	40	19	18	7	22		5	40	21	38	14	31	16	43	19	17	13	30		
	120	15	45	11	33	25	42	23	48	31	25	16	38		5	45	21	42	26	45	25	43	28	20	16	38		
	98	6	41	15	28	24	35	18	37	24	17	15	38		0	35	18	21	25	38	14	38	18	19	11	29		
	103	11	40	13	37	16	33	15	48	17	13	11	39		2	38	14	26	17	43	18	40	20	17	12	28		
	105	4	30	15	33	13	26	13	41	24	15	14	32		7	43	17	39	17	39	18	35	23	21	7	27		
	102	4	24	15	25	17	20	13	30	15	13	15	27		9	37	17	36	12	37	13	34	12	17	9	28		
20.	108	8	46	17	41	24	47	25	35	29	22	11	24		7	47	20	37	23	44	20	44	19	23	15	28		
	103	5	37	12	33	17	40	17	41	19	15	13	27		10	34	23	35	28	37	19	43	16	20	16	37		
	88	2	41	13	31	11	25	18	36	16	15	15	34		2	17	10	34	14	15	11	17	10	10	7	29		
	118	3	37	17	38	17	39	23	41	21	13	14	31		4	42	14	30	21	34	16	44	18	19	10	34		
	105	6	25	15	38	20	32	15	30	19	17	16	35		3	37	16	35	19	37	15	42	14	20	15	36		
	105	7	26	24	43	27	36	17	35	21	15	13	33		8	32	19	42	17	37	19	45	18	21	12	35		

ORIGINAL DATA
MATCHING STUDENTS BY I. Q.

CONTROL GROUP

EXPERIMENTAL GROUP

NAME	I.Q.	FIRE		WATER		WEATHER		SOUND		LIGHT		MAGNETISM		NAME	I.Q.	FIRE		WATER		WEATHER		SOUND		LIGHT		MAGNETISM	
		P	F	P	F	P	F	P	F	P	F	P	F			P	F	P	F	P	F	P	F	P	F		
	113	4	44	23	42	14	44	25	48	31	23	17	38			10	48	21	40	28	46	24	46	15	25	16	37
	109	4	25	12	38	24	37	15	37	19	17	12	35			9	39	16	34	21	40	20	46	17	19	16	35
	102	1	21	15	25	14	30	12	33	17	13	14	30			1	25	16	30	19	33	13	35	15	17	13	33
	85	0	13	13	26	14	17	11	22	9	9	15	30			1	40	19	35	19	26	18	35	20	15	7	20
30.	98	4	25	7	37	15	19	15	28	17	13	14	24			2	37	16	40	17	38	18	41	16	21	11	35
	99	4	31	16	36	16	25	16	37	19	15	15	33			8	27	20	33	13	28	15	38	13	17	15	32
	108	3	30	17	27	17	26	15	46	15	15	15	36			2	35	12	38	14	37	17	42	18	20	11	36
	106	5	45	21	39	14	38	3	45	19	22	17	38			2	30	14	35	14	28	15	27	17	19	11	20
	99	3	20	21	10	14	27	9	27	9	9	11	35			3	31	14	21	12	17	15	38	24	13	11	19
	91	8	30	19	25	13	25	17	36	22	17	15	25			4	35	15	25	9	27	11	38	12	14	15	35
	108	7	46	17	34	17	38	15	45	18	15	17	37			2	32	13	29	18	31	19	40	20	12	13	36
	113	4	37	18	37	13	34	14	39	13	14	15	36			0	37	13	27	12	31	16	39	18	17	13	27
	103	4	45	16	25	16	34	16	35	18	17	15	32			1	38	17	34	25	24	15	32	17	14	10	19
	92	3	30	15	20	13	37	19	36	21	15	15	33			2	20	19	32	7	28	9	36	10	20	15	28
40.	102	5	46	17	31	17	39	18	44	17	16	17	38			3	32	13	43	13	40	23	41	30	17	11	23
	96	5	31	13	28	10	24	15	34	16	7	15	33			7	25	17	35	16	33	12	44	20	16	14	32
	103	3	32	17	29	19	31	18	35	18	12	16	28			8	45	20	32	7	31	18	37	16	16	14	31
	113	5	45	21	38	15	40	15	43	18	13	21	38			0	36	18	38	21	46	19	45	18	20	16	36
	95	8	30	19	30	14	28	12	32	15	15	12	31			1	25	15	35	20	30	14	30	15	18	11	30
	123	11	45	24	43	18	44	21	44	25	13	17	37			2	45	19	43	26	43	23	45	20	25	17	36
	116	6	34	15	38	13	40	19	36	22	16	19	37			2	24	15	24	20	31	13	34	15	17	13	32
	126	13	45	17	47	18	39	22	47	24	19	19	37			10	47	18	43	22	45	21	46	18	21	18	43
	104	2	36	18	26	16	40	9	39	16	11	15	38			2	39	13	36	17	39	19	44	20	22	18	38
	117	1	45	16	23	12	35	13	38	18	19	15	30			2	46	18	41	19	39	25	47	23	19	17	39
50.	115	8	45	14	42	17	36	21	45	16	18	16	36			15	46	22	43	22	45	21	44	21	21	11	36
	113	3	47	17	42	19	47	23	47	17	19	17	31			4	42	12	40	16	32	16	40	9	21	12	35

ORIGINAL DATA FOR
MATCHING BY EXACT PRETEST SCORE

	FIRE			WATER			WEATHER			SOUND			LIGHT			MAGNETISM		
	PRETEST	FINAL (C)	FINAL (X)	PRETEST	FINAL (C)	FINAL (X)	PRETEST	FINAL (C)	FINAL (X)	PRETEST	FINAL (C)	FINAL (X)	PRETEST	FINAL (C)	FINAL (X)	PRETEST	FINAL (C)	FINAL (X)
	7	26	45	17	34	29	19	28	33	15	37	42	18	19	21	15	32	28
	6	45	20	16	28	40	21	29	36	17	31	37	21	17	21	16	29	37
	3	35	37	20	41	35	20	37	30	17	40	43	19	23	22	15	29	35
	2	41	35	19	28	42	21	30	34	13	36	34	14	16	20	11	24	29
	9	42	46	17	18	39	19	44	39	16	39	37	16	12	13	7	25	27
	3	45	46	14	32	31	19	46	26	23	42	47	13	17	15	10	27	32
	7	47	47	19	36	35	7	20	28	16	47	43	18	13	19	17	34	36
	5	21	45	21	34	40	27	45	43	21	44	40	15	21	16	13	28	30
	4	47	47	20	40	37	22	25	45	15	32	34	10	17	20	14	36	32
10.	9	45	37	14	33	32	23	41	44	14	38	40	17	17	19	10	33	29
	1	21	25	16	38	33	16	23	33	16	38	44	12	13	14	10	21	34
	4	35	43	17	40	35	25	42	38	9	37	36	18	13	19	14	29	30
	3	18	36	19	20	32	12	25	44	15	40	27	11	19	10	14	33	36
	5	37	28	14	28	21	16	33	32	11	35	38	21	18	14	11	23	30
	2	20	37	16	28	37	7	15	23	18	37	35	19	18	23	7	22	29
	7	18	25	14	32	26	13	26	40	15	48	41	12	17	17	16	38	36
	10	42	48	13	25	32	17	20	37	11	14	17	24	17	13	15	34	33
	15	45	46	11	33	42	24	47	37	13	41	37	17	13	19	15	36	32
	2	35	45	15	23	20	14	26	28	13	30	41	15	13	25	15	38	37
20.	7	35	27	20	26	37	17	40	34	25	35	43	15	6	18	11	39	29
	6	41	46	15	28	30	11	25	30	15	45	38	15	13	21	7	24	20
	11	40	47	13	37	39	17	39	39	17	41	42	19	15	20	14	32	32
	0	15	37	13	12	34	18	38	44	18	36	44	16	15	17	15	27	28
	2	11	24	15	33	40	20	32	31	23	35	41	19	17	21	11	24	36
	8	46	45	15	25	25	10	20	41	15	30	32	13	14	16	13	39	30
	6	27	31	17	41	36	14	44	30	17	35	39	19	17	16	13	27	27
	5	37	40	15	37	24	24	37	35	15	38	36	17	13	15	15	34	32
	2	41	17	12	33	38	14	30	33	25	48	47	9	9	8	14	31	31
	3	37	31	13	31	27	14	17	34	12	33	44	17	13	14	16	37	38
30.	3	28	46	17	38	37	16	25	34	11	22	27	19	15	17	16	35	35

PRETEST = THE MATCHED PRETEST SCORE

FINAL (C) = FINAL SCORE, CONTROL GROUP

FINAL (X) = FINAL SCORE, EXPERIMENTAL GROUP

FIRE

WATER

WEATHER

SOUND

LIGHT

MAGNETISM

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